PAPI Documentation

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Release 1.2

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Warning: This "Documentation" is still a work in progress; some of the material is not organized, and several aspects of PAPI are not yet covered with sufficient detail.

Welcome! This is the Documentation for *PAPI*, the Data Reduction Pipeline of PANIC instrument, and for *PANIC Quick-Look Tool (PQL)*, the GUI of PAPI used during the observation; all processing routines used by PQL are implented in PAPI.

PAPI is the automatic image processing pipeline for data taken with the PAnoramic Near Infrared Camera (PANIC) for the 2.2m and 3.5m Telescopes at Calar Alto Observatory (CAHA). The pipeline is written in Python and developed at the Institute of Astrophysics of Andalusia (CSIC). The automated processing steps include basic calibration (removeing instrumental signature), cosmic-ray removal, treatment for electronic ghosts (cross-talk), sky subtraction, non-linear count-rate correction, robust alignment and registration.

This manual is a complete description of the data reduction recipes implemented by the PAPI pipeline, showing the status of the current pipeline version and describing data reduction process of the PANIC data using PAPI.

Although PAPI was developed for the PANIC camera, its development was initiated using data from Omega2000 camera at the 3.5m CAHA telescope and HAWK-I camera at the VLT; thus, in principle it should work with data these instruments, although it is not optimized for them.

In addition to this html version of the manual, there is also a pdf version to download.

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Contribution: PANIC Team

CHAPTER ONE

CAVEAT

Currently PAPI it is able to reduce data taken with the Observing Tool (OT) defining the required observing blocks (OB), or manually through GEIRS scripts. PAPI was primarily developed and optimized for reducing broad-band imaging data of extragalactic sources (such as imaging data taken for field galaxy surveys and galaxy cluster surveys). Other types imaging data have been reduced with PAPI but results can not be as good as desired. (See *Troubleshooting* for tips). PAPI is **not** designed to reduce any kind of field taken with PANIC.

CHAPTER

TWO

CONTENTS

2.1 Installation & Configuration

2.1.1 Requirements and Supported Platforms

Because PAPI is written mostly in Python and ANSI C, it can run on any platform that has the required Python modules and GCC compilier. However, it has been developed and deeply tested under openSuSE 12.x/13.x x86_64 Linux OS. Python 2.7.x or higher and the following packages are required:

- NumPy (> v1.6)
- SciPy (> v0.12.2)
- Astropy (> v0.3.1)
- Matplotlib (> v1.3.0)
- PyQt4
- IRAF with STSDAS and MSCRED (v2.16)
- x11iraf for xgterm
- stsci_python (> v2.14)
- CDSClient
- SExtractor (> v2.8.6)
- SCAMP (> v1.7.0)
- SWarp (> v2.19.1)
- Astrometry.net with 42xx index files
- SAO DS9 and XPA (> v7.3b5)
- Montage (v3.3)
- montage_wrapper (0.9.8)

Additional packages are optionally required:

- sphinx to build the documentation

Note: If you are using a SCAMP version <= 2.0.4 (lastest stable version), then you need to install the CDSClient. Otherwise, if you are using SCAM version > 2.0.4, then you need **libcurl**.

Anycase, if you are behind a proxy, you need to set the proxy server in your system:

http_proxy=http//your_proxy:your_port; export http_proxy

2.1.2 Download

The latest stable version of PAPI can be downloaded from GitHub repository .

2.1.3 Building and Installation

PAPI installation is thought to be done as a 'personal user' (non-root), however it should work under any system directory (ie., /usr/local/).

1. To install PAPI as a "personal user" (non-root), follow the next steps:

Once you have installed the required packages described above, you are ready to install PAPI; for this, follow the next steps:

```
$ git clone https://github.com/ppmim/PAPI.git ~/papi
$ cd papi
$ ./papi_setup.sh
```

2. To install PAPI as root on your system, follow the next steps:

```
    $ cd /usr/local
    $ git clone https://github.com/ppmim/PAPI.git papi
    $ cd papi

    Edit the papi_setup.sh and set the right values to PAPI_HOME and PAPI_BIN variables, and ther

    $ ./papi_setup.sh
```

Warning: The script papi_setup.sh is currently implemented **only** for the Bash shell, and will modify your .bashrc file adding a new line at the end.

2.1.4 Building the documentation

The PAPI documentation is base on sphinx. With the package installed, the html documentation can be built from the *doc* directory:

```
$ cd papi/doc
$ make html
```

The documentation will be copied to a directory under *build/sphinx*.

The documentation can be built in different formats. The complete list will appear if you type *make*.

2.1.5 Bug reports

Please submit issues with the issue tracker on github.

2.1.6 Release Notes

- **1.2.x**
  - Support for new MEF structure (Qi); old format (SGi_1) also supported
  - Bug Fixes
- **1.0.x**
  - First version

2.2 PANIC Quick-Look Tool (PQL)

2.2.1 Purpose

PANIC Quick-Look (hereafter PQL) performs some on-line data processing for quick-look or quality check of the data being acquired, taking a close look at a raw near-infrared image and getting a quick feedback of the running observation.

PQL is an application with a graphical user interface which monitors the GEIRS data output, waiting for new FITS files coming from GEIRS. When a new file is detected, it is added to the file list view in the main panel, and then PQL will perform the task previously specified by the user in the setup configuration. Some of the available tasks are:

- Only display the FITS image with no processing
- Dark subtraction, flat division
- Sky subtraction (using N-nearest frames or own sky)
- Field distortion removal
- Image align and stacking
- Preliminary astrometric solution
- Preliminary photometry

In addition, PQL allows you to execute manually in an interactive way some tasks with the data. For example, you will be able to select a file, compute some statistics values (background, FWHM, min, max, . . .) or ask for the sky subtraction looking for the nearest N frames around the selected one. Other option available is to select a set of files and request to shift and align them.

PQL can be operated in both near-real time mode (during the observation) and offline mode (after the observation, with all data files already stored in the disk); however, its functionalities have been provided mainly in near-real time to check the status and progress of the observation during the night.

The visualization application used to display the images is SAOImage ds9, which supports FITS images, multiple frame buffers, region manipulation, and many scale algorithms and colormaps.

2.2.2 FITS files and headers

PQL **only** supports FITS (Flexible Image Transport System) with two-dimensional image formats. Due PANIC has a FPA of four detector, the FITS files can be `Single Extension FITS (SEF)` or `Multi-Extension FITS (MEF)`, however MEF are prefered.

The complete definition of the FITS headers can be found on the GEIRS documentation.

For general purpose, such as viewing and simple analysis, only minimal headers keywords are required. However, and in order to group and reduce observing sequences, the following header keywords are also required:

```
OBS_TOOL= 'OT_V1.1 '            / PANIC Observing Tool Software version
PROG_ID = '        '            / PANIC Observing Program ID
OB_ID   = '6       '            / PANIC Observing Block ID
OB_NAME = 'OB CU Cnc Ks 2'      / PANIC Observing Block Name
OB_PAT  = '5-point '            / PANIC Observing Block Pattern Type
PAT_NAME= 'OS Ks 2 '            / PANIC Observing Secuence Pattern Name
PAT_EXPN=                     1 / PANIC Pattern exposition number
PAT_NEXP=                     5 / PANIC Pattern total number of expositions
IMAGETYP= 'SCIENCE '            / PANIC Image type
```

These keywords are automatically added to the FITS header by the PANIC Observation Tool, as each file is created. If these are not saved, PQL will not work correctly.

2.2.3 Starting PQL

To start PQL GUI, you can lauch it from the PANIC computer (panic22/panic35) once you are logged as obs22/obs35 user. Thus, as any one of the workstations of the observing room, open a X terminal window and log into the PANIC computer as follow:

for 2.2m:

```
$ ssh -X obs22@panic22
(ask Calar Alto staff for password)
```

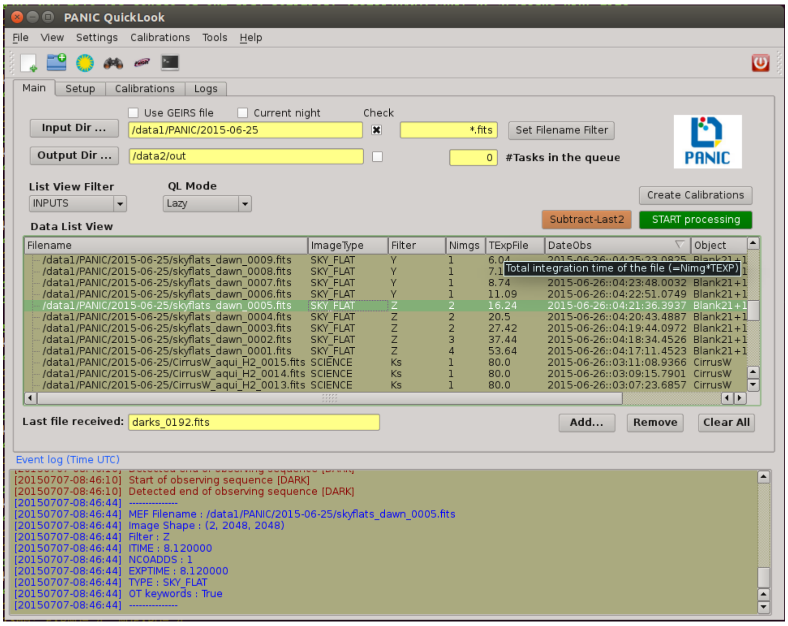
for 3.5m:

```
$ ssh -X obs35@panic35
(ask Calar Alto staff for password)
```

Once you are logged into the PANIC computer, to launch PQL GUI type next command:

```
$ start_ql &
```

The next figure shows a snapshot of the main window of PQL GUI that will bring up the *start_ql* command.



2.2.4 Configuration files

The configuration files used by PQL are located in the $PAPI_HOME/config_files. The main config file is the same file used by PAPI, ie., $PAPI_CONFIG, and usually called papi.cfg.

This file includes a lot of parameters used by PAPI, and therefore by PQL during the processing; however at the end of the $PAPI_CONFIG file there is section called *quicklook*, where the user can set some specific parameters for PQL:

```
##############################################################################
[quicklook]
##############################################################################
# Next are some configurable options for the PANIC Quick Look tool
#
# some important directories
#
source = /data1/PANIC/
output_dir = /data2/out   # the directory to which the resulting images will be saved.
temp_dir = /data2/tmp    # the directory to which temporal results will be saved
```

```
verbose = True

# Run parameters
run_mode = Lazy # default (initial) run mode of the QL; it can be (None, Lazy, Prereduce)
```

Although the user can edit these values in the config file, some of them can be set easily on PQL's GUI.

For the complete list of the parameters available on the $PAPI_CONFIG file, see *Main config file* section.

2.2.5 PQL's main window

PQL Main window contains a Menu bar (1), Tool bar (2), four Tabbed panels (3) and an *Event Log Window* (4). Images are displayed in an external well-known application, ds9. Plots results are displayed in the additional windows, usually generated by matplotlib than can be copied to the clipboard, printed or saved.

Menu bar

The menu bar provides acces to some PQL's capabilities.

1. File
2. View
3. Settings
4. Calibrations
5. Tools
6. Help Opens a web browser which shows an on-line HTML version of this user's manual. This will fail if the internet conection or proxy is not correctly configured.
7. Exit Quit PQL application.

Tool bar

The tool bar duplicates some of the options available from the menu bar or the pop-up menu. Currently, there are several buttons which provide quick access to change the most frecuently-used PQL actions:

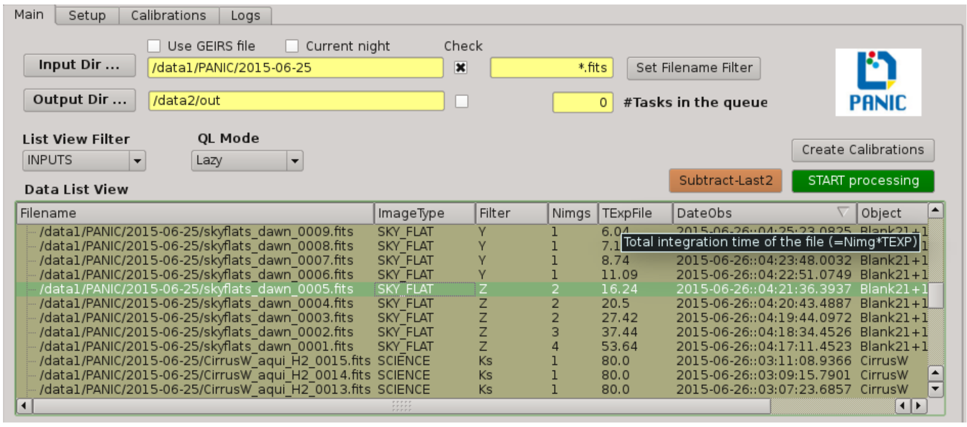
- add a file to the current view
- change the source input directory: the same that *Input directory*.
- display the current selected image: the same that *Display*.
- open an IRAF console
- open Aladin tool
- quit PQL (on the right border)

Main panel

This tab panel contains the following controls:

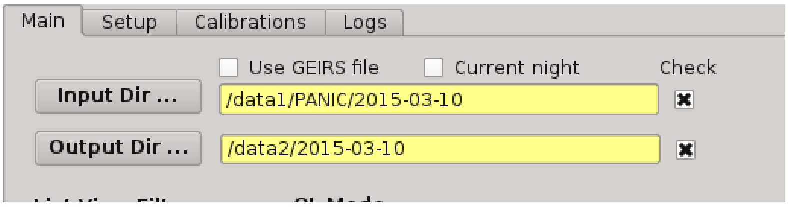
- Input directory
- Ouput directory
- Filename filter
- Current night

- Use GEIRS file
- Data list view
- List view filter
- QL mode
- ‘Subract last-2’ button
- ‘START processing’ button
- ‘Create Calibrations’ button



Data directories

In the ‘Main’ tab panel of PQL main window, the fitst thing to set up are the data directories:



Input directory

This is where you tell PQL where the data are or being saved by GEIRS. This directory is specified at the beggining of the night on the Observation Tool. PQL requieres all data to lie in some main directory, not being required to distribute the files in individual sub-directories for darks, flats, and science images. It is advised that this directory follow the next format:

```
/data1/PANIC/YYYYMMDD
```

To set the value, the user must push the ‘Input Dir’ button:

Note that the value in this field has only effect when the checkbox on the right is clicked.

Output directory

This is where you tell PQL where the data generated by PQL, as result of some processing, will be saved. This directory must also be specified at the begining of the night, and is advised to follow the next format:

```
/data2/out/YYYYMMDD
```

To set the value, the user must push the 'Output Dir' button:

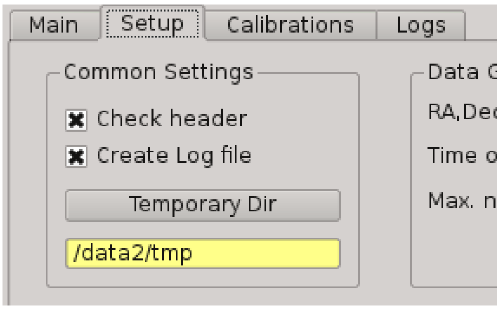
Note that the value in this field has only effect when the checkbox on the right is clicked.

Temporal directory

This is where you tell PQL where the temporal files generated by PQL, as result of some processing, will be saved, and probably deleted after at the end of that processing. This directory must also be specified at the begining of the night, and is advised to follow the next format:

```
/data2/tmp/YYYYMMDD
```

To set the value, the user must push the 'Temporary Dir' button than appears on the 'Setup' tab, instead the 'Main' tab used for input and output directory.



Current night checkbox

When you click this checkbox, the *Input directory* and *Output directory* fields will be automatically filled with the currect night date. If the current night Input/Ouput directories donot exist, PQL will ask you if you want to create them.

The currect night is supposed to start at 8 am (UTC) and to end at 8 am (UTC) of next day.

Use GEIRS file

When this checkbox is clicked, PQL will use the ~/tmp/fitsGeirsWritten file to detect the new files created by GEIRS. Files older than 1 day, will no be considered.

This detection method for FITS files is not frecuently used, but can be useful whether some problem arise reading files just after they have been written by GEIRS.

Filename filter

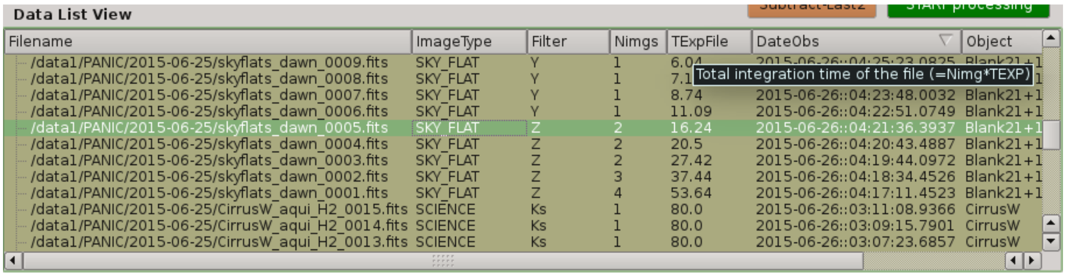
In this box, the user can filter the name of the files should appears on the data list view from the input directory (output files are not filtered). The filter can contains '*' and '?' wildcards.

For example:

> **March10_00?1**

Data list view

Tha data list view control displays all the files found in the input directory, or in the output directory if the check box at the right of output directory is checked. Additionaly, the use can add any other FITS file. The control is a multicolum table with the next fields:



Filename Full path name of the file found in the

Image type The type of the FITS file detected: DARK, DOME_FLAT, SKY_FLAT, FOCUS, SCIENCE

Nimgs Number of images (layers) of the cube; if image is integrated (no cube), then = 1.

TExpFile Total Exposition time of the file (= Nimgs * EXPTIME) (Thus, EXPTIME = TExpFile / Nimgs)

Date-Obs Observation data of the file (DATE-OBS keyword)

Object Object name (OBJECT keyword)

RA Right ascention of center of the image.

Dec Declination of the cener of the image.

You can sort the list by any column (filename, image type, exptime, filter, date-obs, object, right ascension, declination) by clicking on their headers, as usual; by default, the list is sorted by the Date-Obs field, showing the most recect file at the top.

A double-click on any row displays all its file into SAOImage ds9.

For further details of any of the files, you can also look at the header of a fits image using ds9 using the "File/Display Fits Header..." menu option.

List view filter

It allows you to select the type of files to be shown in the data list view. The options are:

INPUTS Files of the input directory

OUTS Files of the ouput directory

DARK Files marked (IMAGETYP) as DARK images

DOME_FLAT Files marked as DOME_FLAT image

FOUCS Files marked as FOCUS image from a focus series

SKY_FLAT Files marked as SKY_FLAT images

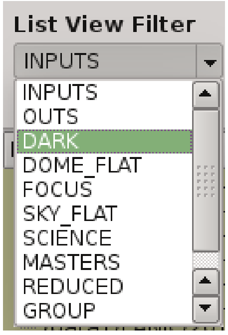
SCIENCE Files marked as SCIENCE image or with unknown type.

MASTERS Files marked as MASTER calibration files produced by PAPI

REDUCED Files marked as calibrated by PAPI

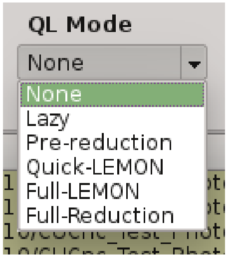
GROUP Special case that show all the files groupped as observed sequences (OBs)

ALL Show all the files, not matter the type of it



QuickLook mode

The quick look mode combo box allows you to select the mode in which PQL will be run when the **START processing** button is pushed. The current modes are:

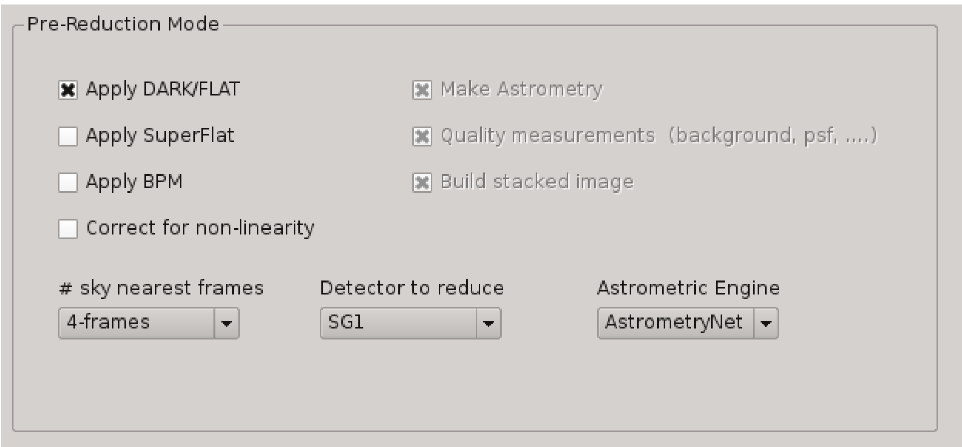


None No processing action is done

Lazy (default) If the end of a calibration (DARK, FLAT) sequence is detected, the master file is built. Otherwise, the SCIENCE files are processed as specified in the 'Setup->Lazy Mode':

- Apply DARK + FLAT + BPM
- Subtract Last Frame (Science)
- Subract Nearest Sky

Pre-Reduction If the end of observing sequence is detected, it is processed in a quick mode (single pass for sky subtraction). For calibration sequences, the master file will be built, and for science sequences, a quick reduction will be done using options configured in the 'Setup->Pre-Reduction Mode' and the calibrations found in local database (output directory and external calibration directory). Note that the pre-reduction options configured in the config file will be overwritten.



Quick-LEMON The same as Pre-reduction, but the processing stops after the 1st sky subtraction, and no final co-added image is produced. It is useful for LEMON processing for light curves.

Full-Reduction If the end of observing sequence is detected, it is processed in a *science* mode (double pass for sky subtraction). For calibration sequences, the master file will be built, and for science sequences, a *science* reduction will be done using options configured in the 'Setup->Pre-Reduction Mode' and the calibrations found in local database (output directory and external calibration directory). Note that the pre-reduction options configured in the config file will be overwritten.

Full-LEMON The same as Pre-reduction, but the processing stops after the 2nd sky subtraction, and no final co-added image is produced. It is useful for LEMON processing for light curves.

Last file received

This field shows the last file received (detected) by PQL.

Buttons

Subract-last2 button

It will produced a new image as result of the subtraction of last two images received.

Create calibrations button

This button will start the processing of all the **calibration** sequences received in the input directory. As result, a list of master calibrations (combined darks or flats) will be generated in the output directory.

START button

This button starts the processing of **all** the sequences received. You will be asked whether to proccess all the current images or only the new ones. As result, a list of master calibrations and science calibrated images will be generated in the *output directory*.

Add button

This button allows to add manually a single file to the *Data List View* from wherever the file is.

Remove button

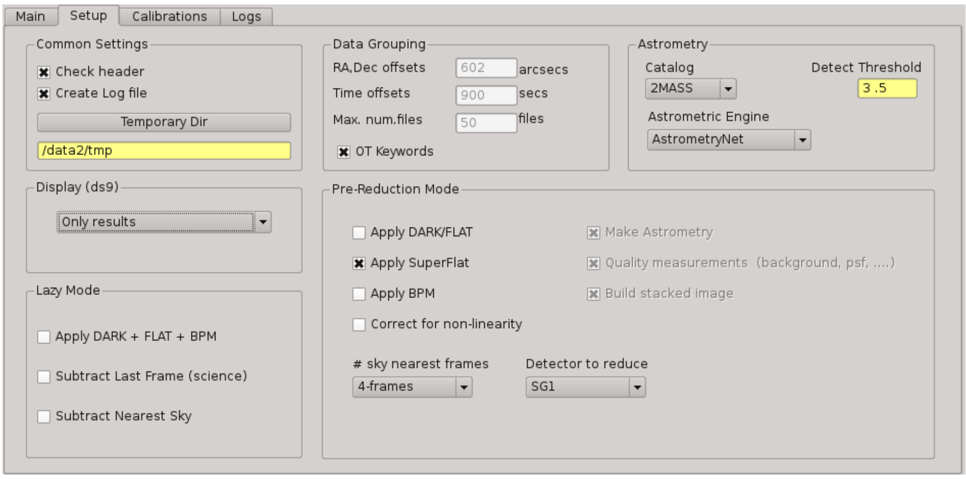
This button removes manually from the *Data List View* the currently selected file, but it does not remove neither from the local database nor the file system.

Clear All button

It removes all the current files from the *Data List View*, but they will not be removed from the file system. As result, it will empty the *Data List View* until a new input directory is selected or a new file is detected in the current one.

Setup Panel

This panel allows the user to set some of the parameters used for the processing. It is divided into six group boxes as shown in next figure:



Common Settings

In this group you can set the next parameters:

1. Check header
2. Create log file
3. Temporary directory

Data grouping

It contains some parameters used for the data grouping when any OT keywords are present; in that case, PQL will try to group the files follwing the *near* in sky and time criterion:

1. RA,Dec offsets:
2. Time offsets:
3. Max. number of files:

If OT keywords are present, then check box 'OT' should be ckecked (default mode).

Astrometry

In this group you can set some parameters related with the astrometric calibration done during the processing:

1. Catalog: reference catalog used for the calibration (2MASS , USNO-B1, GSC 2.2, SDSS-R5)
2. Astrometric Engine: which tool you want to use to the astrometric calibration (SCAMP or Astrometry.net).
3. Detect threshold: the SExtractor threshold to be used to detect sources

Display

Here you can select which files are displayed automatically in the DS9. You have next options:

- Only results (default): only FITS files created in the output directory as result of some processing
- Only new files: only new FITS files detected in the input directory

- All files: both new files detected in the input directory and the results in the output directry.
- None: no files will be displayed

Lazy mode

Under this box, the user can select the operations to be executed when the *Lazy Mode* is activated in PQL. Currectly, the available and exclusive operations are:

- Apply Dark + Flat + BPM
- Subtract Last Frame (science)
- Subtract Nearest Sky

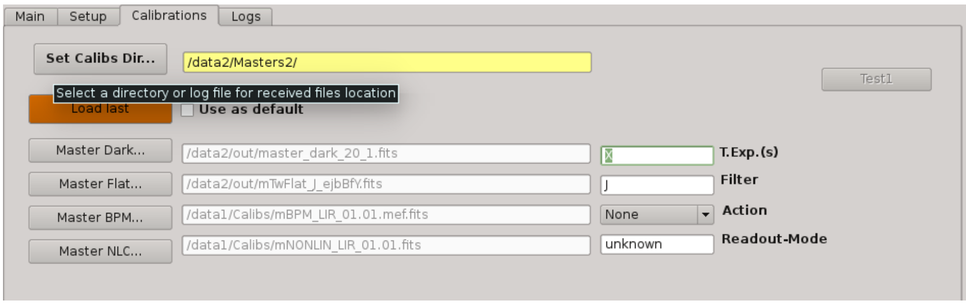
Pre-reduction

Under this box, the user can select the operations to be executed when the *Pre-reduction Mode* is activated in PQL. Currectly, the available and exclusive operations are:

- Apply Dark and FlatField
- Apply SuperFlat (default)
- Apply BPM (Bad Pixel Map)
- Correct for non-linearity
- Select the number of frames to computer the sky bacground: 1-5 (default 4)
- Detector to reduce: SG1 (default), SG2, SG3, SG4, SG123, All

Calibrations panel

This panel allows the user to set some of values for the search of **master** calibration files.



Set Calibs Dir

Pushing this button the user select the additional (external) directory from which the QL will look for **master** calibration files. Normally, it is used to provide to the QL with additional calibrations (dark, flat) from previous nights. Master calibrations found in the *output directory* will have higher priority than those ones.

This directory is also called 'external calibration' in PAPI command line:

```
-C EXT_CALIBRATION_DB, --ext_calibration_db=EXT_CALIBRATION_DB
                        External calibration directory (library of Dark & Flat
                        calibrations)
```

Or *ext_calibration_db* in the *config file*.

Then, if during the reduction of a ReductionSet(RS) no calibrations (dark, flat) are found in the current RS, then PAPI will look for them into this directory. If the directory does not exists, or no calibration are found, then no calibrations will be used for the data reduction. Note that the calibrations into the current RS have always higher priority than the ones in the external calibration directory.

Load last

When this button is pushed, the most recent **master** calibration files found in *output directory* and external calibrations are shown in the fields below.

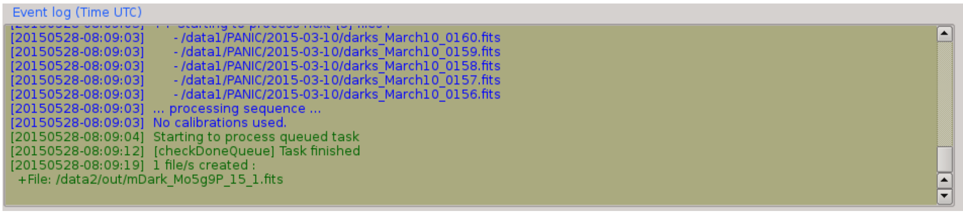
If *Use as default* is click-checked, then the displayed files will be used as default calibrations when *Apply Dark_FlatField_BPM* is run. Otherwise, Apply Dark_FlatField_BPM routine will ask the user for the master calibration files to be used.

Log panel

It is an extension or duplicate of the *Even Log window* of the main panel, but with a wider area for messages.

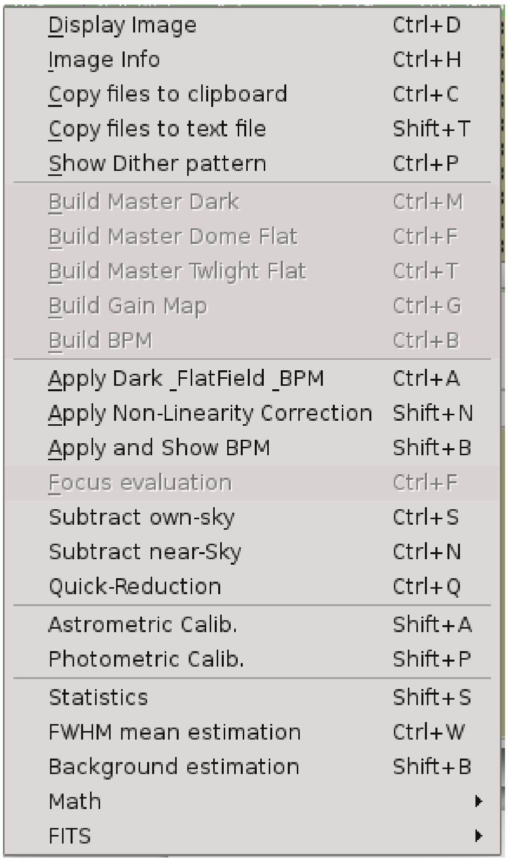
2.2.6 Event log window

The event log window shows important events and results generated by PQL. For example, the filename of the new files generated are shown, or the error produced while the processing of some sequence. This window is used only as output, and you cannot type any command on it.



2.2.7 Pop-up menu

It is a context pop-up menu that appears when the user select a file (or a set of them) in the *Data List View* and click the right mouse button. Next figure shows the options of that pop-up menu:



Some actions in the menu could be disabled and greyed out if they are not availabe or applicable to the selected files.

Display image

It displays the currect selected image in the SAOImage ds9 display; it will launch the ds9 application if it is not opened yet.

Image info

It is a quick way to see some basic information of the selected image. The information is mainly concerning the FITS structure and exposition times used. The information will be shown in the *Event Log Window* as follow:

```
---------------
SEF Filename : /data1/PANIC/2015-05-19_SS_zenith_Ks_1_3/SS_Ks_SG1_4_0024.fits
Image Shape : (32, 32)
Filter : Ks
ITIME : 0.045000
NCOADDS : 1
EXPTIME : 0.045000
TYPE : FOCUS
OT keywords : True
---------------
```

Of course, if you need any other information of the file, you can find it using the 'ds9->File->Display Header...' option.

Copy files to clipboard

It copies the current selected files to the clipboard. This way you could paste the full pathnames to any other file. It is quite useful when using the PAPI commands on the command line to run some operation that is not available

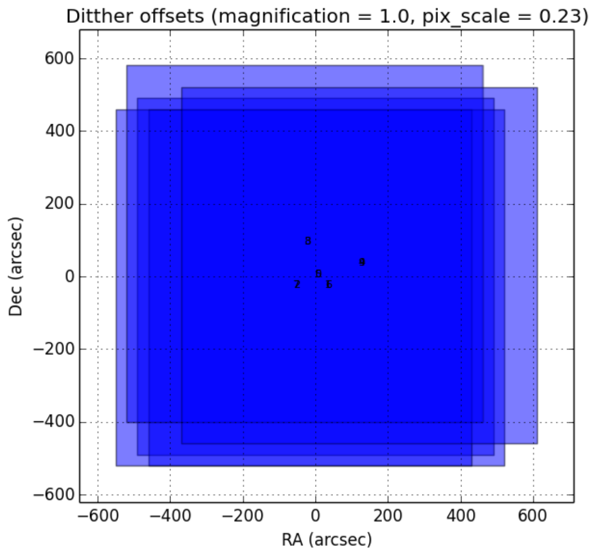
on PQL.

Copy files to text file

If copies the current selected files into the specified text file. It is quite useful when using the PAPI command line to run some operation that is not available on PQL.

Show Dither pattern

It brings up a plot of the full FOV and with the dither offsets obtained from the RA,Dec coordinates found in the FITS header. You have to select a set of images in the *Data List View* and then right-button and *Show Dither pattern*.



Calibrations

Next options allow you to build the master calibration files from a given set of selected files.

Build Master Dark

This command is used to produce a master DARK file combining the set of files currectly selected in the *Data List View*. It checks that all the selected files are compliant, ie., have the same EXPTIME, NCOADD, ITIME, READMODE and shape. You only have to give the name of the master dark file to be created.

The master dark is computed using an average combine with a minmax rejection algorithm.

Build Master Dome Flat

This command is used to produce a Master DOME FLAT file combining the set of files currectly selected in the *Data List View*. It checks that all the selected files are compliant, ie., have the same FILTER, NCOADD, READMODE and shape. You have to select at least one DOME_FLAT_LAMP_OFF and one DOME_FLAT_LAMP_ON image, and then provide the name for the master dome flat to create.

The procedure to create the master dome flat is as follow:

1. Check the EXPTIME , TYPE(dome) and FILTER of each Flat frame
2. Separate lamp ON/OFF dome flats

3. Make the median combine + sigmaclip of Flat LAMP-OFF frames
4. Make the median combine + sigmaclip of Flat LAMP-ON frames
5. Subtract lampON-lampOFF (implicit dark subtraction)
6. (optionally) Normalize the flat-field with median (robust estimator)

Note that we do **not** need to subtract any MASTER_DARK; it is not required for DOME FLATS (it is done implicitly because both ON/OFF flats are taken with the same Exposition Time).

Build Master Twlight (sky) Flat

This command is used to produce a Master SKY FLAT file from a set of files currectly selected in the *Data List View*. It checks that all the selected files are compliant, ie., have the same FILTER, NCOADD, READMODE and shape. You have to select at least three SKY_FLAT images (dusk or dawn). The procedure will look for the required master dark frames to subtract in the current output directory and in the external calibration directory. If some of the master dark are not found, then the procedure will fail.

The procedure to create the master sky flat is as follow:

1. Check the TYPE (sky flat) and FILTER of each Flat frame If any frame on list missmatch the FILTER, then the master twflat will skip this frame and continue with then next ones. EXPTIME do not need be the same, so EXPTIME scaling with 'mode' will be done.
2. Check either over or under exposed frames ([10000 < mean_level < 40000] ADUs)
3. We subtract a proper MASTER_DARK, it is required for TWILIGHT FLATS because they might have diff EXPTIMEs.
4. Make the combine (median + sigclip rejection) the dark subtracted Flat frames scaling by 'mode'.
5. Normalize the sky-flat wrt SG1 detector, dividing by its mean value.

Build GainMap

This command is used to produce a Master GainMap file from a set of files currectly selected in the *Data List View*. It checks that all the selected files are compliant, ie., have the same FILTER, NCOADD, READMODE and shape. You have to select at least three flat frames (dome, dusk or dawn). For sky flats, the procedure will look for the required master dark frames to subtract in the current output directory and in the external calibration directory. If some of the master dark are not found, then the procedure will fail. Dome flat do not need dark subtraction.

The procedure to create the master sky flat is as follow:

1. Check the TYPE (sky flat) and FILTER of each Flat frame If any frame on list missmatch the FILTER, then the master twflat will skip this frame and continue with then next ones. EXPTIME do not need be the same, so EXPTIME scaling with 'mode' will be done.
2. Create the proper master dome/sky flat.

#. Once the master dome flat is created, the procedure will compute the gainmap as follow:

Build BPM

TBC

Apply Dark & FlatField & BPM

This option subtracts a master dark file, then divides by a flat field and finally mask the bad pixels on the current selected files. The master dark and master flatfield files can be searched for automatically into the output and external calibration directories or can be selected manually by the user.

If some of them (dark or flat) are not found or selected (pressing Cancel in the file dialog), then it will not be used or applied.

In the case of the bad pixel mask (BPM), it cannot be selected, but specified in the PAPI config file. However, the user will be asked for about which action to do with the bad pixel mask, whether set bad pixels as NaNs, fix bad pixels with an interpolation algorithm or do nothing with BPM.

Apply Non-Linearity Correction

It applies the Non-Linearity correction to the selected file (or set of files) in the *Data List View* and show the result in ds9; it also set bad pixels to NaN, and will be displayed as green pixels (or the default color configured in ds9->Edit->Preferences->General->Color) on the display.

The corrected image is saved in the output directory with a *_LC* suffix.

The master Non-Linearity correction file used for the correction is defined in the configuration *file*.

Apply and show BPM

This command can be used to apply the BPM to the selected file in *Data List View* the and show the results (NaNs) as green pixels (or the default color configured in ds9->Edit->Preferences->General->Color) on the display.

The bad pixel masked image is saved in the output directory with a *_BPM* suffix.

The master Bad Pixel Mask file used is defined in the configuration *file*.

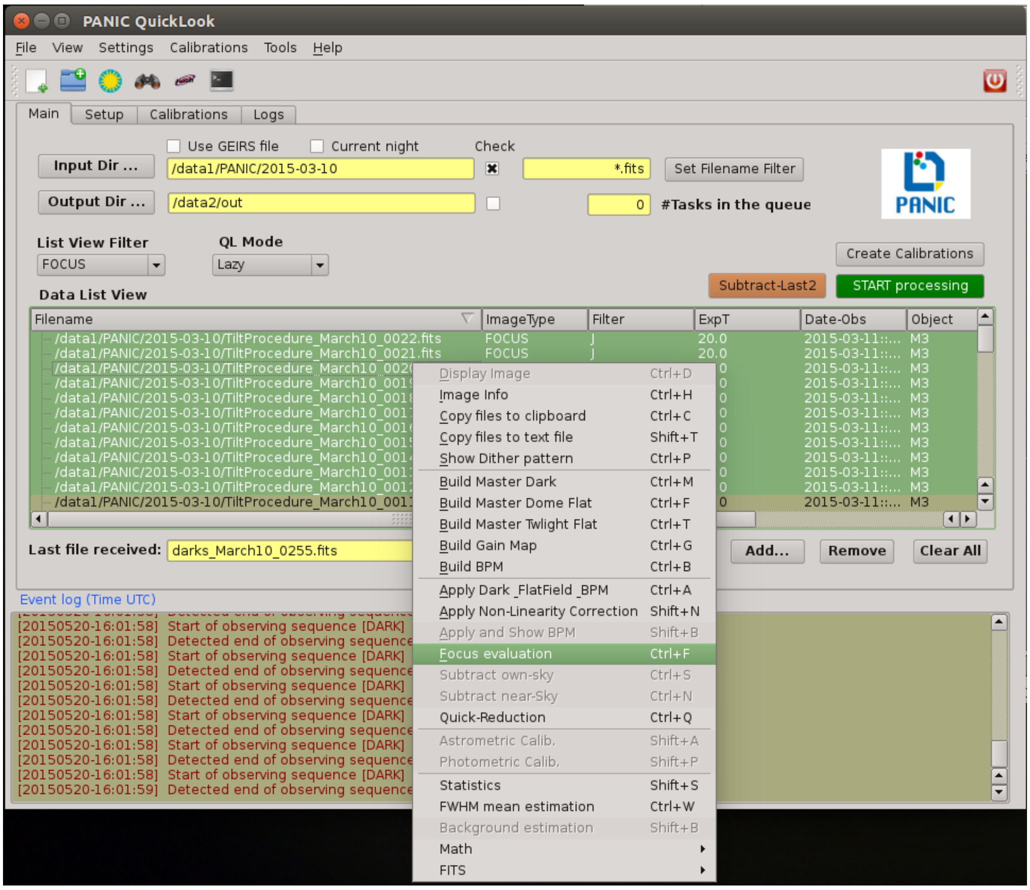
Focus evaluation

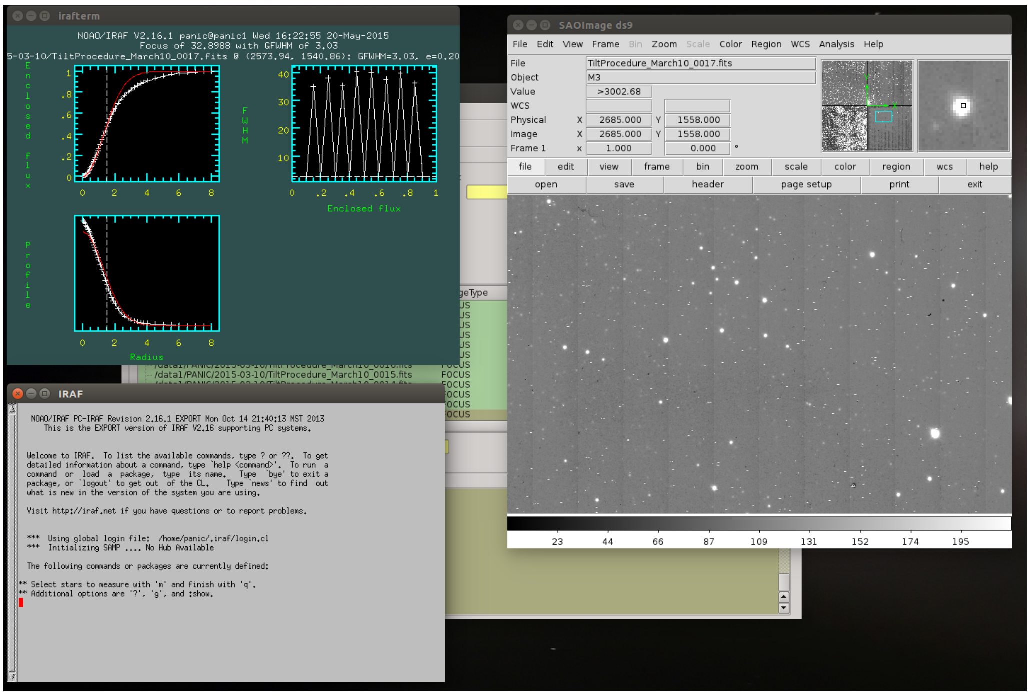
The **Focus evaluation** procedure is based in the IRAF starfocus routine. It only differs on the final plot that is obtained from non-saturated stars, and the best focus is computed computing the curve fit of these points. The PSF size is measured with the the FWHM of the best fit Moffat profile (MFWHM).

Once you have obtained a focus series using the Observation Tool, the procedure to evaluate and get the best focus value for that serie is as follow:

> **Warning:** The input images of the focus series should be saved as SEF (Single Extension FITS), because IRAF starfocus does not works with MEF files. However, if your focus series was saved as SEF, the routine will previously convert to SEF, and then you should not have to do any other conversion.

1. Select the files of the focus series from the *Data List View*
2. Right-click and select **Focus evaluation**. An IRAF console and ds9 windows will bring up, and the first file of the focus series will be displayed on ds9.
3. Focus the mouse over the stars you think are nice for the evaluation and type **m** or **g** (give the profile of the selected star).



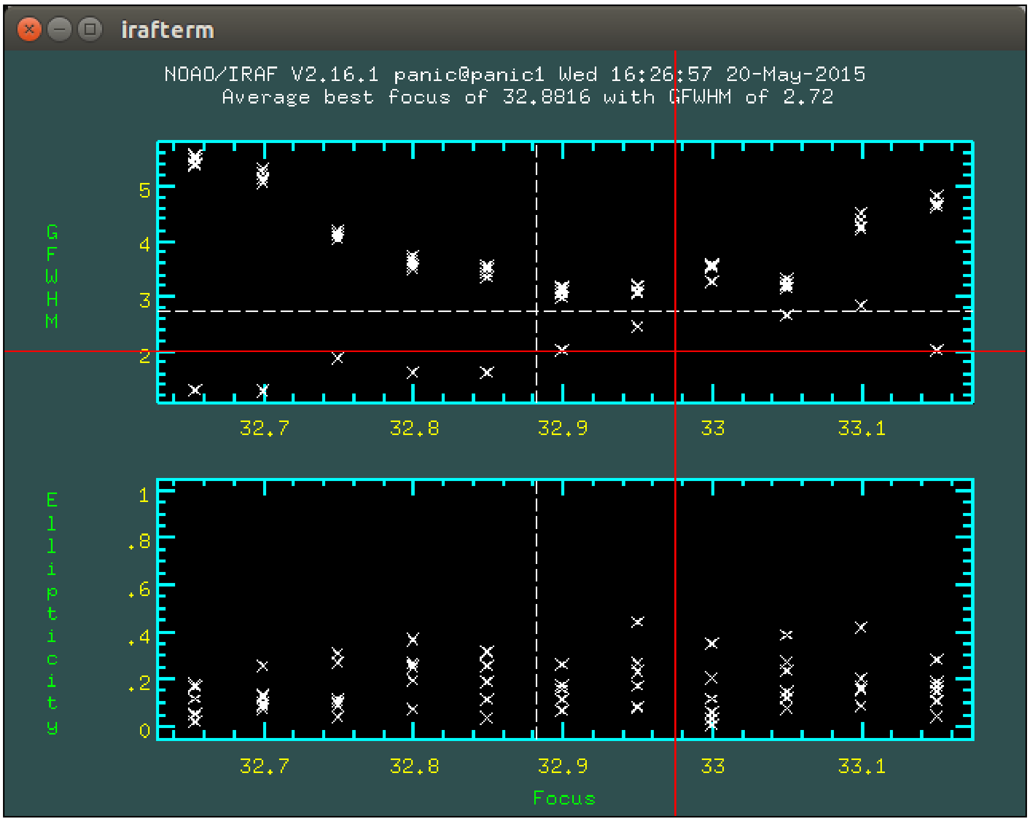


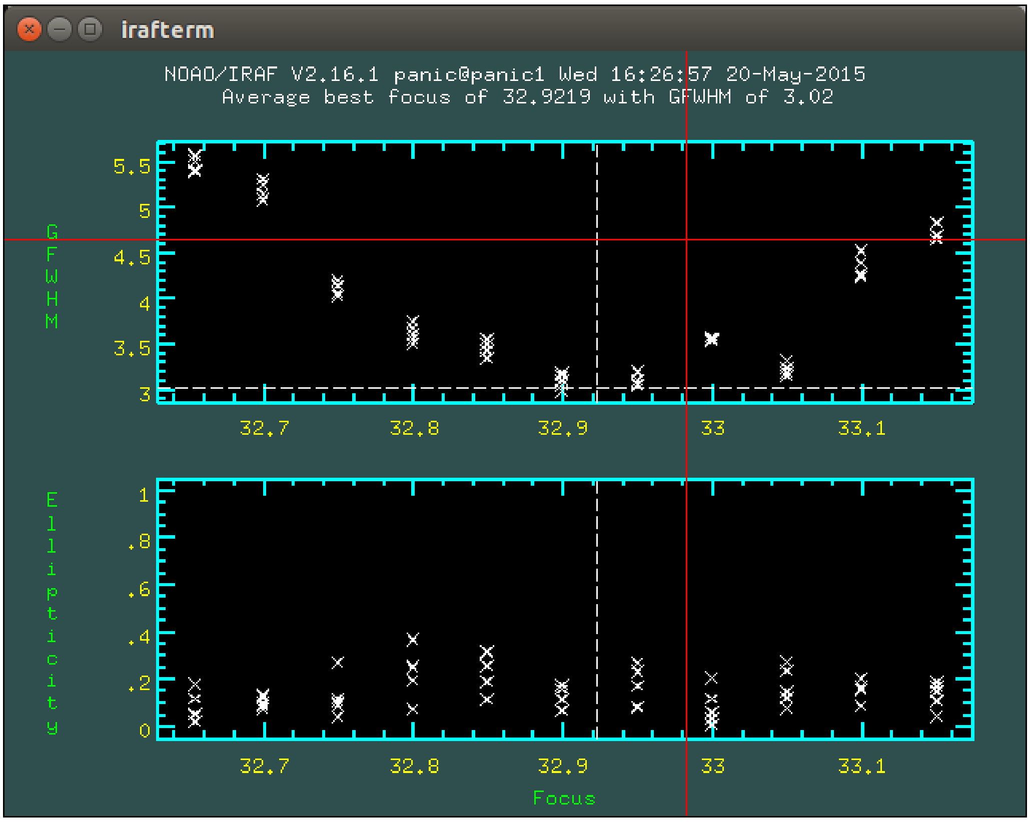
4. When you have finished of selecting all the stars you want for the focus evaluation, type **q**.
5. Then, an IRAF interactive graphics with the first fit will appear, and the best focus obtained. On that

graphics, you should remove the images/stars/focus/points that you consider are not good for the focus evaluation (outliers); for this, type **x** and then i/s/f/p. Type **u** to undo the removing of the outliers. If you need more info about this commands see starfocus

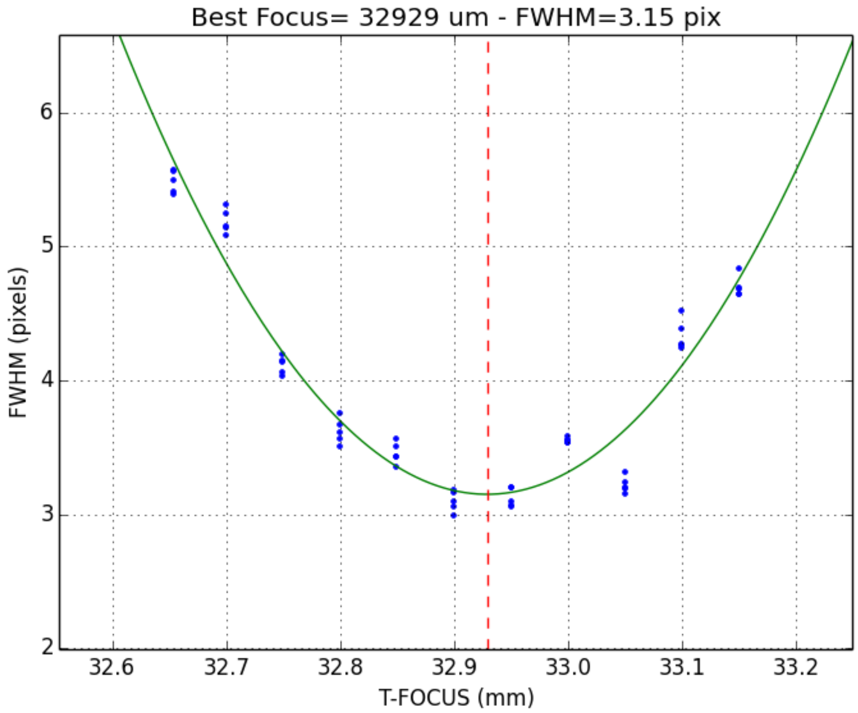
Starfocus Cursor Commands:

```
When selecting objects with the image cursor the following commands are available.

?  Page cursor command summary
g  Measure object and graph the results.
m  Measure object.
q  Quit object marking and go to next image.
At the end of all images go to analysis of all measurements.

:show  Show current results.
When in the interactive graphics the following cursor commands are available. All plots may r

?  Page cursor command summary
a  Spatial plot at a single focus
b  Spatial plot of best focus values
d  Delete star nearest to cursor
e  Enclosed flux for stars at one focus and one star at all focus
f  Size and ellipticity vs focus for all data
i  Information about point nearest the cursor
m  Size and ellipticity vs relative magnitude at one focus
n  Normalize enclosed flux at x cursor position
o  Offset enclosed flux to by adjusting background
p  Radial profiles for stars at one focus and one star at all focus
q  Quit
r  Redraw
s  Toggle magnitude symbols in spatial plots
t  Size and ellipticity vs radius from field center at one focus
u  Undelete all deleted points
x  Delete nearest point, star, or focus (selected by query)
z  Zoom to a single measurement
<space> Step through different focus or stars in current plot type


:beta <val>      Beta parameter for Moffat fit
:level <val>     Level at which the size parameter is evaluated
:overplot <y|n> Overplot the profiles from the narrowest profile?
:radius <val>    Change profile radius
:show <file>     Page all information for the current set of objects
:size <type>     Size type (Radius|FWHM)
:scale <val>     Pixel scale for size values
:xcenter <val>   X field center for radius from field center plots
:ycenter <val>   Y field center for radius from field center plots

The profile radius may not exceed the initial value set by the task
parameter.
```


irafterm
NOAO/IRAF V2.16.1 panic@panic1 Wed 16:26:57 20-May-2015
Average best focus of 32.8816 with GFWHM of 2.72
GFWHM
Ellipticity
32.7
32.8
32.9
33
33.1
Focus


irafterm
NOAO/IRAF V2.16.1 panic@panic1 Wed 16:26:57 20-May-2015
Average best focus of 32.9219 with GFWHM of 3.02
GFWHM
Ellipticity
32.7
32.8
32.9
33
33.1
Focus

5. Once you have removed the outliers, type **q** (with the focus on the plot window) and you will get the final plot with the fit of the values, and the estimation for the best focus of the telescope.



6. Finally, the best focus obtained will be sent to the OT (which will ask you for confirmation) for setting the new telescope focus.

Subtract own-sky

It subtracts the background to the current selected image; the background computation is done using the own image. For this, *-BACKGROUND* option of SExtractor is used.

Subtract near-sky

It subtracts the background to the currect selected image using the closest (in time) images to the currectly selected. Once the close images have been found, PQL asks the user to confirm about them to proceede to the background computation and subtraction.

Quick reduction

It allows you to perform a quick reduction of the selected files (at least 5 files are required) on the *Data List View*.

If you only select one file, then the PQL will look for the nearest (in time) files and ask you to confirm about them and the desired name for the final coadd.

For the quick reducion, the pipeline will use the preferences set up on 'Setup' tab.

Once the quick reducion is done, the filename will be written in the *Event Log Window*, and if selected, it will be display on DS9 display.

Astrometric calibration

Note: Although the input FITS file does not need to be **calibrared**, it is recommended.

The astrometric calibration is built on top of Astrometry.net tool. The command asks you about which detector to use of the calibration (SG1/Q1, SG2/Q2, SG3/Q3 or SG4/Q4).

The new astrometrically calibrated file will be created in the output directory speficied earlier, and will have the same name as the original input file but ending with the *.ast.fits* suffix.

Once the astrometric calibration is done, you could look into the header keyword ROTANGLE, which gives you the rotation angle of the image. It can be useful to check whether the instrument rotator is set properly at the telescope.

Photometric calibration

Note: Your **data is assumed to be calibrated**. Dark subtraction, flat-fielding correction and any other necessary steps should have been performed before any data is fed to the photometric calibration.

We need to first distinguish between absolute and relative photometric calibration. Absolute photometric calibration would be required to determine the system throughput and/or the true magnitude of our stars. Relative photometry is a simpler task that would allow us to measure the uniformity and linearity of response across the detector. This section refers to absolute photometry.

The photometric calibration involves taking sufficiently long integrations with PANIC to get good a good SNR. The night must be photometric and the integration time and zenith angle need to be recorded. To reduce the dependence on zenith angle it would be best to take images within 30º of zenith. The photometric calibration can be performed using the saved images.

The photometric calibration will be useful for validating our throughput calculations. Using the photometric calibration to determine the true magnitudes of stars is more challenging.

Statistics

It gives some statistics (mean, mode, stddev, min, max) values of the currently selected image/s. If the image/s is/are MEF, then the command shows the stats of each extension [1-4], as shown in next example:

```
FILE                                                      MEAN      MODE       STDDEV   MI
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0060.fits[1]  6030.568  2377.875  8704.104  -1
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0060.fits[2]  3069.276  3096.073  866.066  -51
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0060.fits[3]  3852.473  3223.324  4300.289  -2
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0060.fits[4]  3219.446  3060.269  2335.363  -4
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0059.fits[1]  6059.874  2386.128  8698.008  -1
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0059.fits[2]  3106.257  3151.27  849.268  -510
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0059.fits[3]  3862.996  3222.919  4270.374  -2
/data1/PANIC/2015-03-10/Standard_Star_FS27_March10_0059.fits[4]  3258.566  3099.714  2331.496  -4
```

FWHM mean estimation

This command computes the FWHM of the selected image, using the FWHM_IMAGE value returned by SExtractor. For the computation, only stars which fulfill the next requirements are selected:

1. not near the edge of the detector
2. elliticiy < ellipmax (default = 0.3)

3. area > minare (default 32 pix)
4. snr > snr_min (default 5)
5. sextractor flag = 0 (the most restrictive!)
6. fwhm in range [0.1 - 20] (to avoid outliers)

For MEF files, the application will ask you which detector you want to use for the FWHM estimation.

Note: It is worth mentioning that SExtractor does a background subtraction when looking for objects and that the FWHM value is rather imperfect and overestimated compared with IRAF (imexam) values.

E. Bertin: "There are currently 2 ways to measure the FWHM of a source in SExtractor. Both are rather imperfect:

- FWHM_IMAGE derives the FWHM from the isophotal area of the object at half maximum.
- FLUX_RADIUS estimates the radius of the circle centered on the barycenter that encloses about half of the total flux. For a Gaussian profile, this is equal to 1/2 FWHM. But with most images on astronomical images it will be slightly higher.

A profile-fitting option will be available in the next version of SExtractor. I am currently working on it."

Background estimation

This command shows the background image of the currently selected image, using the SExtractor feature 'CHECKIMAGE_TYPE=BACKGROUND'.

Math operations

This option allows the next basic operations with the FITS files selected on the *Data List View*:

1. Sum images: it allows the selection of two or more images; single arithmetic sum will be done.
2. Subtract images: only two images can be selected.
3. Divide images: only two images can be selected.
4. Combine images (median + sigmaclip): it allows the selection of two or more images.

If FITS files are cubes (with the same dimension), then the math operation will be done plane by plane.

FITS operations

This option allows the next conversion operations with the FITS files selected on the *Data List View*:

1. **MEF2Single**: converts a MEF file to SEF file
2. **Single2MEF**: converts a SEF file to MEF file
3. **Split MEF**: extracts the extension (one per each detector) of the MEF file to individual files
4. **Split Single**: extracts the extension (one per each detector) of the SEF file to individual files
5. **Collapse Cube**: sums arithmeticly the planes of the given cube single plane 2D-image
6. **Create DataSeq**: modifies headers of the set of selected FITS files to create a new *Data Sequece* compliant with PAPI as they would be observed with the OT. This command can be usefil to fix or re-order broken sequences (observation was interrupted) or to remove or add files to a observed sequence. You will be asked for the type of sequence (DARK, DOME_FLAT, SKY_FLAT, FOCUS or SCIENCE) you want to create.

2.2.8 How do I ...?

How to determine the telescope focus ?

To determine the telescope focus, you should run a OT focus serie around the guest value and then run the *Focus Evaluation*.

How to determine the field rotation ?

To determine the field rotation, firstly you should observe a enough crowded field and then run the astrometric calibration on it for **each** detector. Once you have the new FITS astrometrically calibrated, you have to look for the *ROTANGLE* keyword in the new header. For example:

```
ROTANGLE=              -0.032836 / degrees E of N
```

How to inspect the profile of the stars in an image ?

You should follow the next steps:

1. select in the *Data List View* the image to inspect.
2. double-click to display the image into ds9 and zoom to the area you wish to inspect
3. go to the tool bar (or Tool menu) and open an IRAF console
4. type in the iraf console 'imexam'
5. focus the mouse cursor on the ds9 display and type the *imexam* comand you wish for the inspection. For example, type ***r*** to show the *radial profile* of the selected star
6. once you have finished the inspection, type q to exit from *imexam*

How do I quick-reduce an observed sequence ?

There are two options:

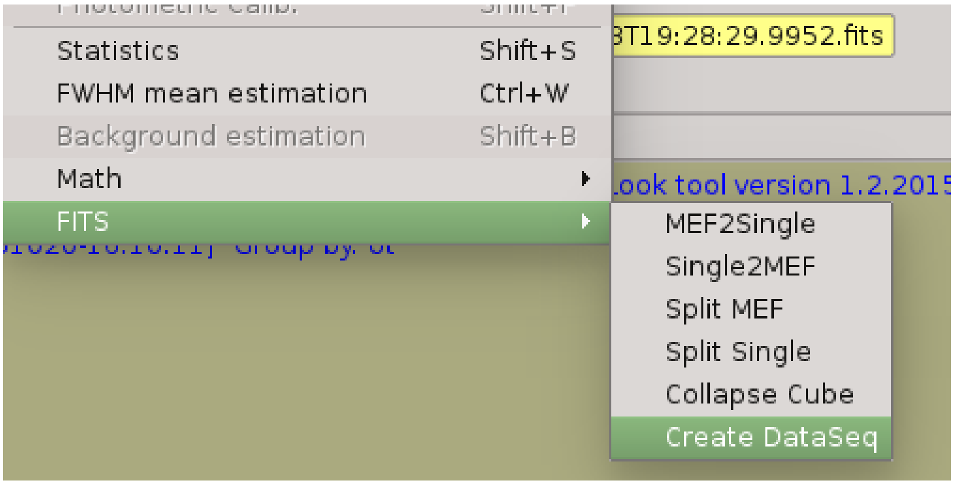
- if you know the files that compose the sequence, you can select them and then right-click and run the *Quick-Reduction* command.
- go to the *List View Filter* and select *GROUP*; then look for the sequence you are looking for in the *Data List View*, right-click and select *Reduce Sequece* command.

For the quick reducion, the pipeline will use the preferences established on 'Setup' tab.

How do I quick-reduce an observed sequence using dark and flat master calibration files ?

You should follow the next steps:

1. Check your sequences are right,ie., they are well-formed and there were no interruption. It some sequece (calibration or science) is not well-formed, the you should use 'FITS->Create DataSeq' menu option in order to fix not well-formed sequence.



2. Create the output directory for the calibrations; then create the calibration pushing 'Create calibrations' button in the main panel.

3. When 'Create calibrations' have finished, go to 'Calibration' tab and select the directory having the master calibrations created just in setep #2.

4. Go to the 'Setup->Pre-reduction Mode' tab and check the option 'Dark/Flat' and select the detectors you want to process (SG1-SG4).

5. Finally, select the sequence you want to reduce, either selecting one by one the files in the *Data List View* or selecting the sequence with the 'Group' classification; then run 'Quick-reduction' from the Pop-up menu.

How do I make mosaics with PQL?

By default, PQL proccess or pre-reduce only the SG1 detector (Q1), and then no mosaic is built. However, you can go to the *Setup Tab* and modify in the *Detector to reduce* combo box the detector/s to reduce; in case of selecting *All* or *SG123* (all less SG4), the corresponding mosaic will be generated.

Currently, PAPI aligns and coadds (using SWARP or Montage, see **mosaic_engine** in *config file*) the images as they are located on the sky to build the mosaic.

How do I make use of parallelisation ?

Just be sure the number of *parallel* parameter is set to *True* on the $PAPI_CONFIG file. When *parallel=True*, the pipeline will reduce each detector in parallel using all the cores available in your computer.

How do I report a issue ?

Please submit issues with the issue tracker on github.

2.3 PAPI

2.3.1 Purpose

PANIC pipeline (hereafter PAPI) performs the automatic data processing both for quick-look and for science quality of the data produced by PANIC. The automated processing steps include basic calibration (removeing instrumental signature, dark and flat-fielding), cosmic-ray removal, treatment for electronic ghosts (cross-talk), sky subtraction, non-linear count-rate correction, robust alignment and registration removing the field distortion.

This chapter gives an introduction in how to get started with PAPI, showing the steps that would normally be necessary to reduce a data set from PANIC. In particular, this example assumes that we have a series of FITS images from an observation run.

2.3.2 Quickstart

Running PAPI can be as simple as executing the following command in a terminal:

```
$ papi.py -s raw_data -d result
```

Where `raw_data` is the directory of the raw dataset (uncalibrated) having both science or calibration files, and `result` is the path to the directory where the calibrated data produced by the pìpeline will be saved.

Example:

```
$ papi.py -s /my/raw_data/directory -d /my/result/directory
```

Optional Arguments

For most image sets PAPI can be run in the default configuration with no additional interaction required. If the default settings are insufficient for processing a particular data set, there are a number of run-time options which may be applied to help improve the reductions.

The next command will show some of the available options:

```
$ papi.py --help
```

Then, the listing of the PAPI command line options:

```
Usage: papi.py [OPTION]... DIRECTORY...

This is PAPI, the PANIC PIpeline data reduction system - IAA-CSIC - Version 1.2.20150508064845

Options:
--version             show program's version number and exit
-h, --help            show this help message and exit
-c CONFIG_FILE, --config=CONFIG_FILE
                        Config file for the PANIC Pipeline application.If not
                        specified, './config_files/papi.cfg' is used.
-s SOURCE, --source=SOURCE
                        Source file list of data frames. It can be a fileor
                        directory name.
-d OUTPUT_DIR, --out_dir=OUTPUT_DIR
                        Output dir for product files
-o OUTPUT_FILE, --output_file=OUTPUT_FILE
                        Final reduced output image
-t TEMP_DIR, --temp_dir=TEMP_DIR
                        Directory for temporal files
-r ROWS, --rows=ROWS  Use _only_ files of the source file-list in the
                        rangeof rows specified (0 to N, both included)
-R, --recursive       Does recursive search for files in source directory
-l, --list            Generate a list with all the source files read fromthe
                        source and sorted by MJD
-M REDUCTION_MODE, --red_mode=REDUCTION_MODE
                        Mode of data reduction to do (quick|science|lab|lemon
                        |quick-lemon).
-m OBS_MODE, --obs_mode=OBS_MODE
                        Observing mode (dither|ext_dither|other)
-S SEQ_TO_REDUCE, --seq_to_reduce=SEQ_TO_REDUCE
                        Sequence number to reduce. By default, all sequences
                        found will be reduced.
-W DETECTOR, --window_detector=DETECTOR
```

```
                        Specify which detector to process:Q1(SG1), Q2(SG2),
                        Q3(SG3), Q4(SG4), Q123(all except SG4), all [default:
                        all]
-p, --print           Print all detected sequences in the Data Set
-T SEQ_TYPE, --sequences_type=SEQ_TYPE
                        Specify the type of sequences to show: DARK,
                        FLAT(all), DOME_FLAT, SKY_FLAT, FOCUS, SCIENCE, CAL,
                        all [default: all]
-b, --build_calibrations
                        Build all the master calibrations files
-C EXT_CALIBRATION_DB, --ext_calibration_db=EXT_CALIBRATION_DB
                        External calibration directory (library of Dark & Flat
                        calibrations)
-D MASTER_DARK, --master_dark=MASTER_DARK
                        Master dark to subtract
-F MASTER_FLAT, --master_flat=MASTER_FLAT
                        Master flat to divide by
-B BPM_FILE, --bpm_file=BPM_FILE
                        Bad pixel mask file
-g GROUP_BY, --group_by=GROUP_BY
                        kind of data grouping (based on) to do with thedataset
                        files (ot |filter)
-k, --check_data      if true, check data properties matching (type, expt,
                        filter, ncoadd, mjd)
-e, --Check           Check if versions of PAPI modules are right.
```

Input FITS data files

GEIRS is capable of saving the frames in different modes (integrated, FITS-cubes, MEF, etc). Next ones are available in the OT when the OP (Observing Program) is defined:

- Multi-Extension FITS (MEF) - Integrated
- Multi-Extension FITS (MEF) - Cube
- Integrated All (SEF - Integrated)
- FITS Cube (SEF - Cube)
- Individual (SEF - Individual)

However, PAPI does not accept any kind of FITS data files available in GEIRS, only the configured in the OT, except *Individual*. As result, PAPI accepts the next type of FITS files (in order of preference):

- Integrated Multi-Extension-FITS (MEF): a unique FITS file with four extensions (MEF), where each extension corresponds to one of the 4 images produced by the single detector chips. If the number of coadd (NCOADDS) is > 0, then they will be integrated (arithmetic sum) in a single image. This is the default and more common saving mode used; in fact, it is the **default** and more wished saving mode. This mode will also be used when the software or hardware sub-windowing is set and the integrated option is selected. Then, there will be an extension for each sub-window.
- Non-integrated Multi-Extension-FITS (MEF): a unique FITS file with four extensions (MEF), one per each detector (or window), having each extension N planes, where N is the number of coadds (NCOADDS), ie. a cube of N planes. This mode will be also used when the software or hardware subwindowing is set up and the no-integrated option is selected.
- Single integrated FITS file: the four detectors are saved in single file and in a single extension FITS image (SEF). If the number of coadds (NCOADDS) is > 0, then they are integrated (arithmetic sum) in a single frame.
- Single non-integrated FITS-cube: the four detectors are saved in a single extension FITS (SEF) file, and each individual exposition in a plane/layer of a cube. It means N planes, where N is the number of coadds or expositions.

Note: Currently PAPI is **not working** with non-integrated *individual* files of an exposition. In case you are interested in no-integrated files and wish to reduce the data with PAPI, you should use SEF of MEF non-integrated FITS-cube mode.

Show grouped files in a raw directory

For the grouping the application uses the *keywords* written by the OT during the observation.

Command:

```
$papi.py -s /my/raw_data/directory -p
```

Example:

```
$papi.py -s /data2/2015-03-10/ -p

[PAPI]: 2015-05-28 09:18:01,484 DEBUG    reductionset:1150: Found 16 groups of files
[PAPI]: 2015-05-28 09:18:01,484 DEBUG    reductionset:1157: ======================================
[PAPI]: 2015-05-28 09:18:01,484 DEBUG    reductionset:1158: =========== GROUPED SEQUENCES (by ot)
[PAPI]: 2015-05-28 09:18:01,484 DEBUG    reductionset:1159: ======================================
[PAPI]: 2015-05-28 09:18:01,484 DEBUG    reductionset:1167: SEQUENCE #[0]  - TYPE= DOME_FLAT   FI
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1168: --------------------------------------
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0042.fits
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0043.fits
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1167: SEQUENCE #[1]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1168: --------------------------------------
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0001_
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0002_
[PAPI]: 2015-05-28 09:18:01,485 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0003_
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0004_
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0005_
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1167: SEQUENCE #[2]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1168: --------------------------------------
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0006_
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0007_
[PAPI]: 2015-05-28 09:18:01,486 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0008_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0009_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0010_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0011_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0012_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0013_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0014_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0015_
[PAPI]: 2015-05-28 09:18:01,487 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0016_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0017_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0018_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0019_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0020_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0021_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0022_
[PAPI]: 2015-05-28 09:18:01,488 DEBUG    reductionset:1167: SEQUENCE #[3]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1168: --------------------------------------
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0023_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0024_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0025_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0026_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0027_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0028_
[PAPI]: 2015-05-28 09:18:01,489 DEBUG    reductionset:1167: SEQUENCE #[4]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1168: --------------------------------------
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0029_
```

```
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0030_
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0031_
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0032_
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0033_
[PAPI]: 2015-05-28 09:18:01,490 DEBUG    reductionset:1167: SEQUENCE #[5]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0034_
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0035_
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0036_
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0037_
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1167: SEQUENCE #[6]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,491 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0038_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0039_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dusk_0040_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1167: SEQUENCE #[7]  - TYPE= SCIENCE   FILT
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,492 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1167: SEQUENCE #[8]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0001_
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0002_
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0003_
[PAPI]: 2015-05-28 09:18:01,493 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0004_
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1167: SEQUENCE #[9]  - TYPE= SKY_FLAT   FIL
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0005_
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0006_
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0007_
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0008_
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1167: SEQUENCE #[10]  - TYPE= SKY_FLAT   FI
[PAPI]: 2015-05-28 09:18:01,494 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0009_
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0010_
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0011_
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0012_
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1167: SEQUENCE #[11]  - TYPE= SKY_FLAT   FI
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0013_
[PAPI]: 2015-05-28 09:18:01,495 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0014_
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1167: SEQUENCE #[12]  - TYPE= SKY_FLAT   FI
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0015_
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0016_
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0017_
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0018_
[PAPI]: 2015-05-28 09:18:01,496 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0019_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0020_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0021_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1167: SEQUENCE #[13]  - TYPE= SKY_FLAT   FI
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1168: ----------------------------------------
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0022_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0023_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0024_
[PAPI]: 2015-05-28 09:18:01,497 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0025_
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0026_
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0027_
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1170: /data2/2015-03-10/skyflats_dawn_0028_
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1167: SEQUENCE #[14]  - TYPE= DARK   FILTER=
```

```
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1168: ------------------------------------------
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1170: /data2/2015-03-10/darks_March10_0251.
[PAPI]: 2015-05-28 09:18:01,498 DEBUG    reductionset:1170: /data2/2015-03-10/darks_March10_0252.
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/darks_March10_0253.
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/darks_March10_0254.
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/darks_March10_0255.
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1167: SEQUENCE #[15]  - TYPE= UNKNOWN   FIL
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1168: ------------------------------------------
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/PANIC.2015-03-10T21
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0002.fits
[PAPI]: 2015-05-28 09:18:01,499 DEBUG    reductionset:1170: /data2/2015-03-10/focus_0016.fits typ
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/focus_0012.fits typ
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0001.fits
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0044.fits
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/focus_0013.fits typ
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/focus_0015.fits typ
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/focus_0014.fits typ
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/domeflats_0041.fits
[PAPI]: 2015-05-28 09:18:01,500 DEBUG    reductionset:1170: /data2/2015-03-10/Standard_Star_FS15_
[PAPI]: 2015-05-28 09:18:01,501 DEBUG    reductionset:1170: /data2/2015-03-10/GJ623_Test_Photom_M
```

Show grouped files per filter and coordinates of a raw directory

Command:

```
$papi.py -s /my/raw_data/directory -g filter -p
```

Reduce (quick) a specificied number of sequences of the group list

To reduce the sequneces from N1 to N2 from the group list obtained with a '-p' command, you have to use the *-S* parameter with two values, N1 and N2, where:

- N1: number of the first sequnece to reduce
- N2: number of the last sequence to reduce

Command:

```
$papi.py -s /my/raw_data/directory -S N1 N2
```

Example:

```
$papi.py -s /data2/2015-03-10/ -S 14 20
```

By default, PAPI process the files in quick mode (single pass for sky subtraction), however if you can use the 'science' mode (double pass for sky subtraction) adding the '-M science' when you run PAPI:

Example:

```
$papi.py -s /data2/2015-03-10/ -S 14 20 -M science
```

If you only want to reduce a specific sequence, for example number 14, you should type:

```
$papi.py -s /data2/2015-03-10/ -S 14 14

[PAPI]: 2015-05-28 09:52:15,122 DEBUG    calDark:283: Saved master DARK to /data2/out/mDark_Xdb5b
[PAPI]: 2015-05-28 09:52:15,122 DEBUG    calDark:284: createMasterDark' finished Elapsed time(s):
[PAPI]: 2015-05-28 09:52:15,123 DEBUG    reductionset:2596: OUTPUT file generated /data2/out/mDar
[PAPI]: 2015-05-28 09:52:15,179 DEBUG    reductionset:3099: Inserting result in DB: /data2/out/mD
[PAPI]: 2015-05-28 09:52:15,211 DEBUG    reductionset:2414: [reduceSet] All sequences processed.
[PAPI]: 2015-05-28 09:52:15,211 DEBUG    reductionset:2415: [reduceSet] Files generated # 1 #: **
[PAPI]: 2015-05-28 09:52:15,212 DEBUG    reductionset:2416:             - /data2/out/mDark_Xdb5bc
[PAPI]: 2015-05-28 09:52:15,212 DEBUG    reductionset:2417:             Sequences failed  # 0 #:
```

Reduce all the sequences of a given directory

Command:

```
$papi.py -s /my/raw_data/directory -d /my/output/directory
```

With this command, the pipeline will reduce all the detected sequences in the /my/raw_data/directory using the default values set in the $PAPI_CONFIG file, and with the reduction mode specified in *reduction_mode* (quick, science, quick-lemon, lemon, lab). However, you can specify the **reduction mode** (quick, science, quick-lemon, lemon) using the *-M* option as follow:

```
$papi.py -s /my/raw_data/directory -d /my/output/directory -M quick
```

Reduce all the sequences of a given set of directories

If you need to reduce all the sequences of a given set of directories, then you should create an script to do that; for example see next bash script:

```
#!/bin/bash
# Script to reduce a set of directories


PAPI=$HOME/bin/papi.py
CONFIG_FILE=$PAPI_CONFIG
MY_DIRS_JAN="2015-03-05 2015-03-06 2015-03-07 2015-03-08 2015-03-09"
for dir in $MY_DIRS
do
    if [ ! -d /data2/out/${dir} ]
    then
        mkdir -p /data2/out/${dir}
    fi
    ${PAPI} -c $CONFIG_FILE -s /data1/PANIC/${dir} -g ot -d /data2/out/${dir} -R science
done
```

Use a specific calibration directory for data reduction

To reduce a complete directory using the calibration found in an specific directory (master dark and flat-field calibrations previously processed), you have to use the '-C path' option. This way, if PAPI cannot find the required calibrations into the input directory (/my/raw/directory), will look for them into the external calibration directory provided (/my/calibration/dir).

Command:

```
$papi.py -s /my/raw_data/directory -d /my/output/directory -C /my/calibrations/dir
```

Enable the Non-Linearity correction for the data processing

If you need to enable to Non-Linearity correction (see *PANIC detector non-linearity correction data*), you only have to edit the $PAPI_CONFIG file and set 'nonlinearity.apply' parameter to 'True'.

Note:: Be ware that when using Non-Linearity correction, all the files used and calibrations, must be non-linearity corrected. Otherwise, you don't get an consistent result.

Reduce a single detector

By default PAPI processes all the detector and builds the mosaic with the reduced detectors. However, if you do not need to reduce all the detectors, but only one of them (Q1...Q4), you can use the option '-W Qx':

```
-W DETECTOR, --window_detector=DETECTOR
                        Specify which detector to process:Q1(SG1), Q2(SG2),
                        Q3(SG3), Q4(SG4), Q123(all except SG4), all [default:
                        all]
```

Example:

```
$papi.py -s /my/raw_data/directory -d /my/output/directory -W Q1
```

2.3.3 Reduction modes

PAPI currectly supports next reduction modes:

- quick (default): single pass for sky background subtraction
- science: double pass for sky background subtraction
- quick-lemon: single pass for sky background and neither alignment nor coadd is done.
- lemon: double pass for sky background subtraction, and neither alignment nor coadd is done.
- lab: for laboratory purposes

For more details, see *Processing description*.

2.3.4 How NOT to use PAPI

PAPI uses a strictly linear approach for data reduction, which makes for easy and transparent processing. And you have to stick to that. It is usually not possible to take data that has been processed half-way by other software and do the rest in PAPI. FITS headers will not be understood, naming conventions not met, and data structures totally incompatible.

2.3.5 Configuration files

PAPI has a set of configuration files required to run properly. They are the next ones:

- papi.cfg: main configuration file

  In addition to the command line options, PAPI has a configuration file in which the user can set both the command line options and a wider set of additional ones. This config file can be specified with the `-c` option, but by default it is looked for it in the `config_files` directory defined by PAPI_CONFIG environment variable.

- scamp.cfg: SCAMP configuration file
- swarp.conf: SWARP configuration file
- sextractor.sex : SExtractor configuration file
- sextractor.conf:
- sextractor.cong:
- sextractor.nnw:
- sextractor.param:

2.3.6 Examples

TBD

2.3.7 Main config file

This file has a structure similar to that of Microsoft Windows INI files. It is divided into "sections", each of which has a number of "name = value" entries. The order in which sections appear is not important.

Any plain text editor can be used to do edit the file. If some section or keyword is missing, the application will fail and inform about that.

File papi.cfg:

```
# Default configuration file for PAPI 1.3
# updated 24 Jul 2015

##############################################################################
[general]
##############################################################################

#
# Instrument (pani,o2k,hawki): if INSTRUME keyword does not match, an error
# will be throw. Letters not case-sensitive.
#
instrument = PANIC


#
# Some important directories
# nOTE: oUTPut dir must be different from Quick-Look
#source = /home/jmiguel/DATA/SIMU_PANIC_3/q1.txt   # it can be a directory or a text file with a l
source = /data1/PANIC
output_dir = /data2/out   # the directory to which the resulting images will be saved.
temp_dir = /data2/tmp    # the directory to which temporal results will be saved (avoid trailing s

#
# If no outfile name is given (None), the result of each sequence reduced.
# will be saved with a filename as: 'PANIC.[DATE-OBS].fits',
# where DATE-OBS is the keyword value of the first file in the sequence.
output_file = /tmp/reduced.fits

#
# Decide if parallel processing capabilities will be activated (True),i.e., split the processing
# of each PANIC detector separatelly.
# Otherwise (False), all be processed sequencially.
parallel = True
ncpus = 8  # Number of CPU's cores to used for parallel processing

verbose = True # currently not used

logfile = /tmp/papi.log # to be implemented !!!

#
#reduction_mode : reduction mode to do with the raw science files
#
reduction_mode = quick   # default reduction mode (quick|science|lemon|quick-lemon|lab)

#
# detector: detector to reduce/process (Q1,Q2,Q3,Q4,all).
# For O2k, this parameter has no effect.
# Q1=ext1 - [0:2048, 0:2048]       - SG4 (for CAM_DETROT90=2) -- the bad detector
# Q2=ext2 - [2048:4096, 0:2048]    - SG1
# Q3=ext3 - [0:2048, 2048:4096]    - SG3
# Q4=ext4 - [2048:4096,2048:4096] - SG2
#
# Since GEIRS-r731M-18 version, new MEF extension naming:
#           EXTNAME = 'Qi_j'
```

```
#           DET_ID = 'SGi_j' (same ids as before)
# and the order in the MEF file is Q1,Q2,Q3,Q4,Q123 (all except Q4)
detector = all


#
obs_mode = dither  #default observing mode of input data files to reduce (dither|ext_dither|other
#

# if any, default master calibration files to use
#master_dark = None
#master_flat = None
#master_bpm = None

#
# External calibration DataBase: directory used as an external calibration database.
# Then, if during the reduction of a ReductionSet(RS) no calibration (dark, flat)
# are found in the current RS, then PAPI will look for them into this directory.
# If the directory does not exists, or no calibration are found, then no calibrations
# will be used for the data reduction.
# Note that the calibrations into the current RS have always higher priority than
# the ones in the external calibration DB.
#
ext_calibration_db = /data2/Masters2/

#
# check data integrity. It consists in checking if TEXP,NCOADD,FILTER and READMODE match properly
#
check_data = True

#
# Remove crosstalk. If True, a procedure to remove the crosstalk will be executed
# just after the 1st/2nd. sky subtraction (both O2K or PANIC).
#
remove_crosstalk = True

#
# Cosmic-Ray Removal. If True, a procedure to remove the CR will be executed
# just after the 2nd. sky subtraction.
# It has only sense for LEMON output, because CR should be
# removed during the stack combine (co-adding with SWARP).
#
remove_cosmic_ray = False

#
# Purge output. If True, a procedure to remove the temporal or intermediate files
# (.list, .objs., .ldac, .xml, ...) will be removed from the output directory
# just after the end of the RS reduction.
#
purge_output = True


#
# Estimate FWHM after reduction of each sequence
#
estimate_fwhm = False

# min_frames : minimun number of frames required to reduce a sequence
#
min_frames = 5

#
# group_by: the pipeline will try to group the data files in two main ways:
```

```
#           (OT) following the specific keywords provided by the OT as OB_ID, OB_PAT, IMAGETYP, FI
#           and then different observing sequences could be grouped and reduced or
#           (FILTER) only group by filter band, and then only one observing sequence should be pro
#           (NONE) No grouping criteria will be taken; force only one group with all the files
#
group_by = ot # (OT or FILTER or NONE)

# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
# The ABOVE option values can be modified at the invokation time of the pipeline in the command li
# !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!

#
# apply_dark_flat : 0  Neither dark nor flat field will be applied.
#                   1  The pipeline will look for a master dark and master flat
#                      field to be applied to the raw science frames.
#                      Both master DARK and FLAT are optional,i.e., each one
#                      can be applied even the other is not present.
#                      It no DARK/FLAT are found, the reduction continues
#                      without apply them, but implicity due to skysubtraction (superflat).
#                   2  Master flat will be looked for to be applied AFTER
#                      skysubtraction, but no DARK will be subtracted (it is
#                      supposed to be done by the skysubtraction)
#                      (some people think they are not required !)
apply_dark_flat = 1

#
# some other values (really required ?)
#

# Maximum seconds (10min=600secs aprox) of temporal distant allowed between two consecutive frames
max_mjd_diff = 900
max_ra_dec_offset = 2602 # Maximum distance (arcsecs) allowed for two consecutives frames into a s
max_num_files = 50 # Maximum number of files allowed in a sequence (only for 'filter' grouping)


pix_scale = 0.45   # default pixel scale of the images

equinox = 2000      # equinox in years

radecsys = ICRS     # reference system

pattern = *.fits    # if specified, only those images that match the pattern (according to the rul
                    # considered when autodetecting FITS images in _directories_ no tilde expansio
                    # ranges expressed with [] will be correctly matched. NOTE: it is because thi
                    # or discarded_.... specify its type at the beginning of they filename (vamos,

filter_name_Z = Z   # the key stored in the FITS header when the filter is Z
filter_name_Y = Y
filter_name_J = J
filter_name_H = H, Filter_H    # admits list of strings if multiple values are possible
filter_name_K = K
filter_name_Ks = KS


# Coadd mode (2nd pass, ie., final coadd): dithercubemean | swarp
# 'dithercubemean': it uses the irdr::dithercubemean routine, and then requires
# image offsets computed with offsets.c
# 'swarp': it uses the astrometric calibration to register the images with SWARP;
# it is more time consuming than 'cubemean' due to it runs :Astrometry.Net + SEx + SCAMP + SWARP
# Note: for the 1st coadd for object mask, dithercubemean is **always** used
# to avoid the distortion correction.
#coadd_mode = dithercubemean
coadd_mode = swarp
```

```
# Dilatation of the object mask
# Due to field distortion, it is recommended to dilete the object mask
# in order to have a 'good' object masking for the 2nd-skysubtraction pass.
# Next value is a mult. scale factor to expand object regions; default
# is 0.5 (ie, make 50% larger)
dilate = 0.2

# Mosaic engine: tool to be used to build the final mosaic with the 4 detectors
# 'swarp': use SWARP from Astromatic.net - not always work
# 'montage': use Montage tool - in principle, the best option
# 'other': no mosaic is built, but a MEF with 4 extensions
# For more information see: http://www.astrobetter.com/blog/2009/10/21/better-ways-to-make-large-i
mosaic_engine = montage


##############################################################################
[config_files]
##############################################################################
# Next paths are relative to PAPI_HOME environment variable

irdr_bin = irdr/bin
sextractor_conf = config_files/sextractor.sex     # SExtractor configuration file
sextractor_param = config_files/sextractor.param  # File containing the list of parameters that wi
sextractor_nnw = config_files/sextractor.nnw      # File containing the neutal-network weights for
sextractor_conv = config_files/sextractor.conv    # File containing the filter definition
scamp_conf = config_files/scamp.conf              # SCAMP configuration file
swarp_conf = config_files/swarp.conf              # SWarp configuration file


##############################################################################
[nonlinearity]
##############################################################################
# Non Linearity correction (apply=True)
apply = False

# FITS file containing the NL model for correction
model_lir = /data1/Calibs/mNONLIN_LIR_01.01.fits
model_rrrmpia = /data1/Calibs/mNONLIN_RRR-MPIA_01.01.fits

##############################################################################
[bpm]
##############################################################################
# Bad Pixel Mask mode:
# - fix: Bad Pixels are replaced with a bi-linear interpolation from nearby pixels.
#   Probably only good for isolated badpixels;
# - grab: no fix BPM, but only set to NaN the bad pixels. It will be taken
#   into account in GainMaps.
# - none: no action will be done with the BPM
# BPMask ==> Bad pixeles >0, Good pixels = 0
mode = grab

# FITS file containing the BPM (bad pixels > 0, good_pixels = 0)
#bpm_file = /data1/Calibs/bpm_lir_v01.00.fits
bpm_file = /data1/Calibs/mBPM_LIR_01.01.mef.fits
#bpm_file = /data1/Calibs/master_bpm_lir_ones.join.fits
##############################################################################
[dark]
##############################################################################

# object_names: in order to make it possible to work in batch mode, is it
# possible to run the PANIC dark module in all the images, specifying in
# this parameter which ones will be considered. That is, only those images
```

```
# whose object name matchs one of the names listed in this parameter will be
# considered when generating the master dark.
#
# Note that if '*' is contained in the list, _all_ object names will be matched.
# This symbol, thus, provides a way to easily specify all the images, which is
# equivalent to saying "do not filter images by their object names".
#
object_names = dark

# check_prop : if true, the dark frames used to build the master dark will be
# checkd to have the same acquisition properties (EXPT,NCOADD,ITIME, READMODE)
#
check_prop = yes


# suffix: the string, if any, to be added to the filename of each resulting
# image. For example, for suffix = "D" and the imput file /home/images/ferM_0720_o.fits,
# the resulting image would be saved to /home/images/ferM_0720_o_D.fits.
# This parameter is optional, as if nothing is specified, nothing will be appended
#
suffix = D


# min_frames : minimun number of frames required to build a master dark
#
min_frames = 5




##############################################################################
[dflats]
##############################################################################

# object_names: in order to make it possible to work in batch mode, is it
# possible to run the PANIC flat module in all the images, specifying in
# this parameter which ones will be considered. That is, only those images
# whose object name matchs one of the names listed in this parameter will be
# considered when generating the master dome flat
#
# Note that if '*' is contained in the list, _all_ object names will be matched.
# This symbol, thus, provides a way to easily specify all the images, which is
# equivalent to saying "do not filter images by their object names".
#
object_names = DOME_FLAT_LAMP_OFF, DOME_FLAT_LAMP_ON

# check_prop : if true, the frames used to build the master  will be
# checkd to have the same acquisition properties (EXPT,NCOADD,ITIME, READMODE, FILTER)
#
check_prop = yes

# suffix: the string, if any, to be added to the filename of each resulting
# image. For example, for suffix = "D" and the imput file /home/images/ferM_0720_o.fits,
# the resulting image would be saved to /home/images/ferM_0720_o_D.fits.
# This parameter is optional, as if nothing is specified, nothing will be appended
#
suffix = F


# min_frames : minimun number of frames required to build a master dome flat
#
min_frames = 5
```

```
area_width = 1000       # length in pixels of the central area used for normalization

# median_smooth: median filter smooth of combined FF to reduce noise and improve
# the S/N and preserve the small-scale (high-frequency) features of the flat
#
median_smooth = False

##############################################################################
[twflats]
##############################################################################

# object_names: in order to make it possible to work in batch mode, is it
# possible to run the PANIC flat module in all the images, specifying in
# this parameter which ones will be considered. That is, only those images
# whose object name matchs one of the names listed in this parameter will be
# considered when generating the master twflat
#
# Note that if '*' is contained in the list, _all_ object names will be matched.
# This symbol, thus, provides a way to easily specify all the images, which is
# equivalent to saying "do not filter images by their object names".
#
object_names = TW_FLAT_DUSK, TW_FLAT_DUSK, SKY_FLAT

# check_prop : if true, the  frames used to build the master will be
# checkd to have the same acquisition properties (EXPT,NCOADD,ITIME, READMODE, FILTER)
#
check_prop = yes

# suffix: the string, if any, to be added to the filename of each resulting
# image. For example, for suffix = "D" and the imput file /home/images/ferM_0720_o.fits,
# the resulting image would be saved to /home/images/ferM_0720_o_D.fits.
# This parameter is optional, as if nothing is specified, nothing will be appended
#
suffix = F


# min_frames : minimun number of frames required to build a master twlight flat
#
min_frames = 3

area_width = 1000       # length in pixels of the central area used for normalization

# median_smooth: median filter smooth of combined FF to reduce noise and improve
# the S/N and preserve the large-scale features of the flat
#
median_smooth = False

##############################################################################
[gainmap]
##############################################################################

# object_names: in order to make it possible to work in batch mode, is it
# possible to run the PANIC gainmap module in all the master flat images, specifying in
# this parameter which ones will be considered. That is, only those images
# whose object name matchs one of the names listed in this parameter will be
# considered when generating the gain map.
#
# Note that if '*' is contained in the list, _all_ object names will be matched.
# This symbol, thus, provides a way to easily specify all the images, which is
# equivalent to saying "do not filter images by their object names.
#
object_names = MASTER_SKY_FLAT, MASTER_DOME_FLAT, MASTER_TW_FLAT
```

```
mingain = 0.1 # pixels with sensitivity < MINGAIN are assumed bad (0.7)
maxgain = 1.9 # pixels with sensitivity > MAXGAIN are assumed bad (1.3)
nsigma =  10  # badpix if sensitivity > NSIG sigma from local bkg (5.0)
nxblock = 16  # image size should be multiple of block size (16)
nyblock = 16  # (16)
normalize = yes # if 'yes' apply a previous normalization to master flat images

area_width = 1000   # area to use for normalization (1000)

##############################################################################
[skysub]
##############################################################################
# Used for: createObjMask, skySubtraction
# object_names: in order to make it possible to work in batch mode, is it
# possible to run the PANIC skysubtration module in all the images, specifying in
# this parameter which ones will be considered. That is, only those images
# whose object name matchs one of the names listed in this parameter will be
# considered when generating the master dark.
#
# Note that if '*' is contained in the list, _all_ object names will be matched.
# This symbol, thus, provides a way to easily specify all the images, which is
# equivalent to saying "do not filter images by their object names".
#
object_names = SKY, SKY_FOR

# check_prop : if true, the dark frames used to build the master  will be
# checkd to have the same acquisition properties (EXPT,NCOADD,ITIME, READMODE, FILTER)
#
check_prop = yes

# suffix: the string, if any, to be added to the filename of each resulting
# image. For example, for suffix = "D" and the imput file /home/images/ferM_0720_o.fits,
# the resulting image would be saved to /home/images/ferM_0720_o_D.fits.
# This parameter is optional, as if nothing is specified, nothing will be appended
#
suffix = S

#
# min_frames : minimun number of frames required to build a master super flat
#
min_frames = 5

# half width of sky filter window in frames
#
hwidth = 2

area_width = 1000       # length in pixels of the central area used for normalization

# Object mask
mask_minarea = 10    # sex:DETECT_MINAREA (min. # of pixels above threshold)
mask_maxarea = 0     # sex:DETECT_MAXAREA (SExtractor> 2.19.5, max. # of pixels above threshold; (
mask_thresh = 3.5   # sex:DETECT_THRESH used for object masking (1.5)
#expand_mask = 0.5   # amount to expand the object mask regions

#
# sex:SATUR_LEVEL: level (in ADUs) for a single exposure image at which the pixel
# arises saturation. Note than that value should be updated with NCOADDS or NDIT
# keywords when present in the header. So,
```

2.4 Image selection

2.5 Data-set classification

One of the main featthe value specified here is for a # single image with NCOADD = 1. # Of course, this values will be specific for each detector, and in case of # a multi-detector instrument, should be the lowest value of all detectors. # satur_level = 55000

2.6 Image selection

2.7 Data-set classification

One of the main feat # skymodel : sky model used used during the sky subtraction. It will be a # parameter for the IRDR::skyfilter() executable # (median) the normal way for coarse fields [default] # (min) suitable for crowded fields # skymodel = median

Method used to compute the dither offsets (only for 1st pass): # - wcs: using the astrometric calibration and coordinates of the center of # the images. # - cross-correlation: no astrometric calibration required, use irdr:offsets # cross-reference offset algorithm. For big offsets and sparse/poor fields, # it not recommended. # Note: for the object mask registering in the 2nd pass of skysub, wcs is # the method always used (hardcoded). method = wcs #method = cross-correlation

single_point: If true, means that the SEextractor objmask will be reduced to a # single point (centroid) to run the cross-reference offset algorithm,i.e., # each object is represented by a single, one-valued pixel, located at the # coordinates specified by its X_IMAGE and Y_IMAGE parameters in the # SExtractor catalog. # It is done mainly to avoid problems with large object masks (extended objtects, # satured objects, etc ..) that make the cross-reference algorithm too slow # and even might with wrong results. # single_point = False

Object mask mask_minarea = 10 # sex:DETECT_MINAREA (min. # of pixels above threshold) mask_maxarea = 0 # sex:DETECT_MAXAREA (SExtractor> 2.19.5, max. # of pixels above threshold; 0=unlimited) mask_thresh = 2.5 #5.0 # sex:DDETECT_THRESH used for object masking

sex:SATUR_LEVEL: level (in ADUs) for a single exposure image at which the pixel # arises saturation. Note than that value should be updated with NCOADDS or NDIT # keywords when present in the header. So, the value specified here is for a # single image with NCOADD = 1. # Of course, this values will be specific for each detector, and in case of # a multi-detector instrument, should be the lowest value of all detectors. # satur_level = 55000

Minimun overlap correlation fraction between offset translated images # (from irdr::offset.c) # min_corr_frac = 0.1

Maximun dither offset (in pixels) allowed to use a single object mask # # In order to know if a single/common object mask (deeper) or multiple (individual) # object masks for each sky-subtracted file is needed. # For values > max_dither_offset, and due to the optical distortion, # multiple (individual) masks are used; otherwise a common object mask got from # the first coadd. # max_dither_offset = 200

Astrometric engine (SCAMP or AstrometryNet) engine = AstrometryNet #engine = SCAMP

Object mask mask_minarea = 20 # sex:DETECT_MINAREA (min. # of pixels above threshold) mask_maxarea = 0 # sex:DETECT_MAXAREA (SExtractor> 2.19.5, max. # of pixels above threshold; 0=unlimited) mask_thresh = 3.5 # sex:DETECT_THRESH used for object masking #expand_mask = 0.5 # amount to expand the object mask regions

sex:SATUR_LEVEL: level (in ADUs) for a single exposure image at which the pixel # arises saturation. Note than that value should be updated with NCOADDS or NDIT # keywords when present in the header. So, the value specified here is for a # single image with NCOADD = 1. # Of course, this values will be specific for each detector, and in case of # a multi-detector instrument, should be the lowest value of all detectors. # satur_level = 50000

catalog = 2MASS # Catalog used in SCAMP configuration (2MASS, USNO-A1, USNO-A2, # USNO-B1,SC-1.3, GSC-2.2, GSC-2.3, UCAC-1, UCAC-2, UCAC-3, # NOMAD-1, PPMX, DENIS-3, SDSS-R3, SDSS-R5, SDSS-R6 or SDSS-R7)

The pipeline is designed for the PANIC data files. You should change # this options in case you were going to work with images whose keywords are # not the same.

object_name = IMAGETYP # Target description julian_date = MJD-OBS # Modified Julian date x_size = NAXIS1 # Length of x-axis y_size = NAXIS2 # Length of y-axis ra = RA, CRVAL1 # Right ascension, in decimal degrees | The list defines the priority in which the values are read dec = DEC, CRVAL2 # Declination, in decimal degrees | That is, if "DEC" is not found, CRVAL2 will be read, and so on. filter = FILTER # Filter name

Next are some configurable options for the PANIC Quick Look tool # # some important directories # #source = /data/O2K/Feb.2012/120213 # it can be a directory or a file (GEIRS datalog file) #source = /mnt/GEIRS_DATA #source = /home/panic/GEIRS/log/save_CA2.2m.log #source = /mnt/tmp/fitsfiles.corrected #source = /home/panic/tmp/fitsfiles.corrected source = /data1/PANIC/ #source = /home/panic/tmp/fitsGeirsWritten output_dir = /data2/out # the directory to which the resulting images will be saved. temp_dir = /data2/tmp # the directory to which temporal results will be saved verbose = True

Run parameters run_mode = Lazy # default (initial) run mode of the QL; it can be (None, Lazy, Prereduce)

Although all parameteres of the config file ($PAPI_CONFIG) are important, some of them have special relevance to the right execution and in the results obtained (in bold are default values):

- apply_dark_flat: (0 | **1** | 2)
- remove_crosstalk: (**True** | False)
- nonlinearity::apply: (True | **False**)
- ext_calibration_db: (path)
- group_by: (**ot** | group)
- bpm::mode (**none** | fix | grab)
- mode = None

No BPM file will be read. Bad Pixels will be determined using the GainMap obtained from the Superflat or Skyflat. During sky-filtering, the computed bad pixels (from gainMap) will be replaced with NaNs. However, in science mode, on the first pass of skyfilter and in order to get a good object mask, the bad pixels will be replaced by the background level.

- mode = grab

Read (if exists) BPM file; read bad pixels will be added to bad pixels computed in the gainmap. During sky-filtering, the bad pixels (read + computed) will be replaced by NaN. However, in science mode, on the first pass of skyfilter and in order to get a good object mask, the bad pixels will be replaced by the background level.

- mode = fix

Read (if exists) BPM file; read bad pixels will be replaced by bi-linear interpolation during dark and flat-fielding and before sky filtering (sky subtraction). During sky-filtering, bad pixels computed in the gainMap will be replaced with the background level.

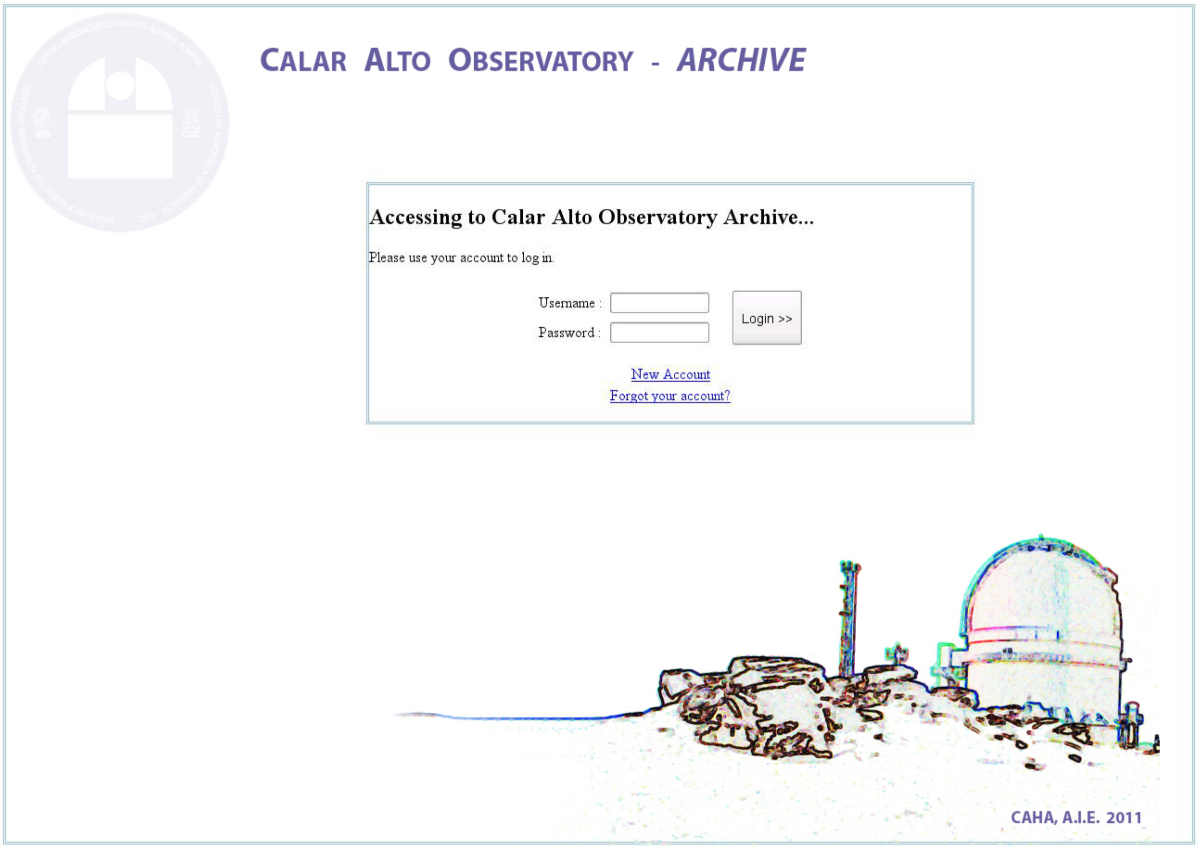
The prefered mode is 'grab' whether you want to use a BPM file, or none if you do not.

2.7.1 Getting PAPI Data

PAPI requires the full set of uncalibrated data products and best reference files for each observation in the input image set. These files can be readily obtained through the CAHA archive. When requesting data from CAHA you need to specify:

- Instrument : **PANIC**
- Science Files Requested: **Uncalibrated - Raw**

- Reference Files: **Advanced Data Products**



2.7.2 Caveats

As we stated previously, PAPI was developed primarily for reducing NIR imaging data of any kind of sources (galactic, extragalactic, coarse or crowed fields, and extended objects). Here are some tips for reducing each types of data:

- Coarse fields:
- Crowded fields:
- Extended objects:

Add tips here

2.8 PAPI Reference

Release 1.2

Date October 20, 2015

> **Warning:** This "Reference" is still a work in progress; some of the material is not organized, and several aspects of PAPI are not yet covered sufficient detail.

2.8.1 Modules

The PAPI pipeline consists of a set of processing modules which implement from basic calibration to generating final co-added registered mosaics (See table below). These modules can be run as a stand alone routines depending

of your needs, e.g. to create a master dark or flat-field for calibration, or you can use them as a pipeline calling the main script `papi`, which will use each of the modules as they are needed in order to accomplish a complete data reduction of a set of raw images.

Main Modules	Description
`papi`	Main pipeline script to start the entire data reduction process
`applyDarkFlat`	Finds out the best Focus value from a focus series
`astrowarp`	Creates final aligned and coadded frame using SEx, SCAMP and SWARP
`calBPM`	Creates a master Bad Pixel Mask from a set of darks and flats calibration files
`calCombineFF`	Combine a dome Flat-field and a sky Flat-field into a new Flat-field
`calDark`	Creates a master dark by combination of a dark sequence
`calDarkModel`	Creates a master dark model from a dark series
`calDomeFlat`	Creates a master Dome Flat
`calSuperFlat`	Creates a master Super Flat from a set of object or sky frames
`calTwFlat`	Creates a master Twilight Flat
`calGainMap`	Creates a Gain Map from any master flat
`correctNonLinearity`	Corrects the images pixel values for non-linearity
`dxtalk`	Removes cross-talk spots from input images
`makeobjmask`	Creates a objects mask (SExtractor OBJECTS images) for a list of FITS images.
`photometry`	Performs a photometric calibration comparison with 2MASS
`solveAstrometry`	Performs a astrometric calibration using Astrometry.net and 42xx index files
`remove_cosmics`	Detects and clean cosmic ray hits on images based on Pieter van Dokkum's L.A.Cosmic algorithm.
`eval_focus_serie`	Estimates the best focus value of a focus exposures
`cleanBadPix`	Cleans masked (bad) pixels from an input image.

Utilities	Description
`createDataSeq`	Modifies headers of a set of FITS files to create a Data Sequece compliant with PAPI
`getBPM`	Creates the BPM file from the NonLinearity correction MEF file. The bad pixels will be saved as 1's
`mef`	Tool to convert from SEF to MEF and viceversa; also allows to give splits of the extensions or join SEFs.
`collapse`	Collapses (add them up arithmetically) each cube of a list files into a single 2D image.
`genLogsheet`	Generates a text file as a log sheet from a set of images.
`imtrim`	Crops/cuts the input image edges
`modFITS`	Allows to perfom the modification of any FITS keyword
`runStarfocus`	Run IRAF.starfocus for a focus sequece and return the best focus value and a plot of the fit.
`runPsfmeasure`	Run IRAF.psfmeasure for a focus sequece and get field FWHM of given stars
`getDarks`	Gives the unique values of [read_mode, itime, ncoadd, save_mode] of a set of files of a given directory. Used to know the DARKS required from them.
`getImageOffsets`	Gives the image offsets (arcsecs) based on the WCS of the image headers

papi

Description:

The papi module (see *PAPI*) is the main PAPI module to run the data reduction. It starts by creating a subdirectory in the `output_dir` directory using the name give on the command line or in the $PAPI_CONFIG file. Within the run directory a [Q1-Q4] subdirectories, one for each detector, will be created. The temporal files will be saved (and deleted at the end) in the `temp_dir` directory.

Syntax:

```
Usage: papi.py [OPTION]... DIRECTORY...

This is PAPI, the PANIC PIpeline data reduction system - IAA-CSIC - Version 1.2.20150508064845
```

```
Options:
--version             show program's version number and exit
-h, --help            show this help message and exit
-c CONFIG_FILE, --config=CONFIG_FILE
                        Config file for the PANIC Pipeline application.If not
                        specified, './config_files/papi.cfg' is used.
-s SOURCE, --source=SOURCE
                        Source file list of data frames. It can be a fileor
                        directory name.
-d OUTPUT_DIR, --out_dir=OUTPUT_DIR
                        Output dir for product files
-o OUTPUT_FILE, --output_file=OUTPUT_FILE
                        Final reduced output image
-t TEMP_DIR, --temp_dir=TEMP_DIR
                        Directory for temporal files
-r ROWS, --rows=ROWS  Use _only_ files of the source file-list in the
                        rangeof rows specified (0 to N, both included)
-R, --recursive       Does recursive search for files in source directory
-l, --list            Generate a list with all the source files read fromthe
                        source and sorted by MJD
-M REDUCTION_MODE, --red_mode=REDUCTION_MODE
                        Mode of data reduction to do (quick|science|lab|lemon
                        |quick-lemon).
-m OBS_MODE, --obs_mode=OBS_MODE
                        Observing mode (dither|ext_dither|other)
-S SEQ_TO_REDUCE, --seq_to_reduce=SEQ_TO_REDUCE
                        Sequence number to reduce. By default, all sequences
                        found will be reduced.
-W DETECTOR, --window_detector=DETECTOR
                        Specify which detector to process:Q1(SG1), Q2(SG2),
                        Q3(SG3), Q4(SG4), Q123(all except SG4), all [default:
                        all]
-p, --print           Print all detected sequences in the Data Set
-T SEQ_TYPE, --sequences_type=SEQ_TYPE
                        Specify the type of sequences to show: DARK,
                        FLAT(all), DOME_FLAT, SKY_FLAT, FOCUS, SCIENCE, CAL,
                        all [default: all]
-b, --build_calibrations
                        Build all the master calibrations files
-C EXT_CALIBRATION_DB, --ext_calibration_db=EXT_CALIBRATION_DB
                        External calibration directory (library of Dark & Flat
                        calibrations)
-D MASTER_DARK, --master_dark=MASTER_DARK
                        Master dark to subtract
-F MASTER_FLAT, --master_flat=MASTER_FLAT
                        Master flat to divide by
-B BPM_FILE, --bpm_file=BPM_FILE
                        Bad pixel mask file
-g GROUP_BY, --group_by=GROUP_BY
                        kind of data grouping (based on) to do with thedataset
                        files (ot |filter)
-k, --check_data      if true, check data properties matching (type, expt,
                        filter, ncoadd, mjd)
-e, --Check           Check if versions of PAPI modules are right.
```

PAPI creates a in-memory SQLite database to store the uncalibrated input data fits headers and pipeline metadata.

Results:

FITS file/s with coadd as result of the reduction and calibration of the specified sequences; otherwise, the error will be shown in the console and log file.

Examples:

The following example reduce, in quick mode, all the sequences of the given directory:

```
$papi.py -s /my/raw_data/directory -d /my/output/directory -M quick
```

applyDarkFlat

This module receives a series of FITS images and applies basic calibration: subtract and divide by the given calibration files (master dark and master flat-field).

Options:

```
-h, --help            show this help message and exit
-s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                      Source file listing the filenames of raw frames
-d DARK_FILE, --dark=DARK_FILE
                      Master dark to be subtracted
-f FLAT_FILE, --flat-field=FLAT_FILE
                      Master flat-field to be divided by
-o OUT_DIR, --out_dir=OUT_DIR
                      Directory where output files will be saved
```

astrowarp

The `astrowarp` module performs the alignment and warping of a set of images, in principle previously reduced, but not mandatory. The module uses the Astromatic packages sextractor , scamp and swarp to accomplish this task.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -c CONFIG_FILE, --config_file=CONFIG_FILE
                        config file
  -s SOURCE_FILE, --source=SOURCE_FILE
                        Source file list of data frames. It can be a file or directory name.
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        final coadded output image
  -v, --verbose         verbose mode [default]
```

Example:

```
$ astrowarp.py -c papi.cfg -s /tmp/test_files.txt -o /tmp/astrowarp.fits
```

calBPM

This module creates a master Bad Pixel Map (.pl iraf file) from a set of dome (on and off) flats.

The algorithm followed to create the BPM is the next:

1. Classify/split the frames in 3 sets (DOME_FLAT_LAMP_ON, DOME_FLAT_LAMP_OFF, DARKS) and and check whether there are enough calib frames
2. Check the master dark (Texp)
3. Subtract the master dark to each dome flat
4. Combine dome dark subtracted flats (on/off)
5. Compute flat_low/flat_high
6. Create BPM (iraf.ccdmask)

Usage:

```
Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        list of input (optionally  corrected) dome ON and OFF flat images..
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        The output bad pixel mask.
  -L LTHR, --lthr=LTHR  The low rejection threshold in units of sigma [default 20]
  -H HTHR, --hthr=HTHR  The high rejection threshold in units of sigma [default 20]
  -D MASTER_DARK, --master_dark=MASTER_DARK
                        [Optional] Master dark frame to subtract
  -S, --show_stats      Show statistics [default False]
  -v, --verbose         verbose mode [default]
```

Example:

```
$ calBPM.py -s /tmp/domesF.txt -D /tmp/masterDark.fits -o /tmp/masterBPM.pl
```

calCombineFF

Combine a master dome Flat-field and a master sky Flat-field into a combined master Flat-field. The procedure followed is :

The procedure for taking advantage of the facts that the large-scale flat-field variation of the dark-sky flat match that of the program frames and the dome flats have very high S/N in each pixel goes as follows:

(a) Median smooth the combined, dark-sky flat -this improves the S/N and preserves the large-scale features of the flat.

(b) Median smooth the combined dome flats using the same filter size as was used for the dark-sky flat.

(c) Divide the combined dome flat by it's median smoothed-version. The result is a frame that is flat on large scales but contains all the high spatial frequency flat-field information.

(d) Now multiply the smoothed dark-sky frame and the result of the division in the previous step.

As result a flat-field with the low spatial frequency properties of the dark-sky flat combined with the high S/N, high spatial frequency properties of the dome flat is obtained.

Usage:

```
$ calCombineFF.py [options] arg1 arg2 ...

Module to combine a dome Flat-field and a sky Flat-field.

Options:
  --version             show program's version number and exit
  -h, --help            show this help message and exit
  -d DOMEFF, --domeFF=DOMEFF
                        input dome Flat-Field
  -s SKYFF, --skyFF=SKYFF
                        input sky Flat-Field
  -o OUTPUT_IMAGE, --output=OUTPUT_IMAGE
                        output filename of combined Flat-Field (default = combinedFF.fits)
```

Example:

```
$ calCombineFF.py -d /data/masterDF.fits -s /data/masterSF.fits -o /data/masterFF.fits
```

calDark

The `calDark` module receives a series of FITS images (master darks) and create the master dark and computer several statistics.

Usage:

```
Usage: calDark.py [options] arg1 arg2 ...

Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file listing the filenames of dark frames.
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        final coadded output image
  -n, --normalize       normalize master dark to 1 sec [default False]
  -e, --scale           scale raw frames by TEXP [default False]
  -S, --show_stats      Show frame stats [default False]
  -t, --no_type_checking
                        Do not make frame type checking [default False]
  -v, --verbose         verbose mode [default]

   Usage: calDark.py [options] arg1 arg2 ...
```

Example:

```
$ calDark.py -s /data/PANIC_V0/dark_seq.txt -o /data/out/masterDark.fits
```

calDarkModel

The `calDarkModel` module performs a dark model. To do that, a input dark series exposures with a range of exposure times is given. Then a linear fit is done at each pixel position of data number versus exposure time. A each pixel position in the output map represents the slope of the fit done at that position and is thus the dark current expressed in units of data numbers per second. The dark model obtained will be a FITS files with two planes (extensions):

- plane 0 = dark current in DN/sec
- plane 1 = bias

DARKCURRENT value: The median dark current in data numbers per second found from the median value of the output dark current map.

Usage:

```
Usage: calDarkModel.py [options] arg1 arg2 ...

Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file listing the filenames of dark frames.
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        final coadded output image
  -S, --show_stats      Show frame stats [default False]
```

Example:

```
$ calDarkModel.py -s /tmp/darkModel.txt -o /tmp/darkModel.fits
```

calDomeFlat

The `calDomeFlat` module creates a master flat field from dome flat observations, a bad pixel map an various statistics.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file list of data frames. It can be a file or directory name.
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        final coadded output image
  -n, --normalize       normalize master flat by median. If image is multi-detector,
  -m, --median_smooth   Median smooth the combined flat-field [default False]
  -v, --verbose         verbose mode [default]
```

Example:

```
$ calDomeFlat -s /tmp/domeFlats.txt -o /tmp/masterDF.fts -n
```

calSuperFlat

The `calSuperFlat` module creates a master super flat field from science observations, a bad pixel map an various statistics.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file list of data frames. It has to be a fullpath file name
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        output file to write SuperFlat
  -b BPM, --bpm=BPM     bad pixel map file (default=none)
  -N, --norm            normalize output SuperFlat. If image is multi-chip, normalization wrt chi
  -m, --median_smooth   Median smooth the combined flat-field (default=False)
```

Example:

```
$ calSuperFlat.py -s /tmp/test_files.txt  -o /tmp/superFlat.fits -N
```

calTwFlat

This module receives a series of FITS images (twilight flats) and a master dark model and creates the master twilight flat-field.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file list of data frames. It can be a file or directory name.
  -d MASTER_DARK, --master_dark_model=MASTER_DARK
                        Master dark model to subtract each raw flat (it will be scaled by TEXP)
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        final coadded output image
  -b MASTER_BPM, --master_bpm=MASTER_BPM
                        Bad pixel mask to be used (optional)
  -n, --normalize       normalize master flat by median. If image is multi-detector,then normaliz
  -m, --median_smooth   Median smooth the combined flat-field [default False]
  -L MINLEVEL, --low=MINLEVEL
                        flats with median level bellow (default=1000) are rejected
  -H MAXLEVEL, --high=MAXLEVEL
                        flats with median level above (default=100000) are rejected
  -v, --verbose         verbose mode [default]
```

Example:

```
$ calTwFlat.py -s /tmp/twflats.txt -d /tmp/darkModel.fits  -o /tmp/masterTF.fits -n
```

calGainMap

The `calGainMap` module creates a master gain map from a master flat field (dome, twilight or superflat) NOT normalized and previously created. The flatfield will be normalized to make a gainmap and set bad pixels to 0.

Usage:

```
Options:
-h, --help            show this help message and exit
-s SOURCE_FILE, --source=SOURCE_FILE
                        Flat Field image NOT normalized. It has to be a fullpath file name (requi
-o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        output file to write the Gain Map
-L MINGAIN, --low=MINGAIN
                        pixel below this gain value  are considered bad (default=0.5)
-H MAXGAIN, --high=MAXGAIN
                        pixel above this gain value are considered bad (default=1.5)
-x NXBLOCK, --nx=NXBLOCK
                        X dimen. (pixels) to compute local bkg (even) (default=16)
-y NYBLOCK, --ny=NYBLOCK
                        Y dimen. (pixels) to compute local bkg (even) (default=16)
-n NSIGMA, --nsigma=NSIGMA
                        number of (+|-)stddev from local bkg to be bad pixel (default=5)
-N, --normal          if true, the input flat-field will be normalized before build the gainmap (
```

Example:

```
$ calGainMap.py -s /tmp/masterTF.fits -o /tmp/masterGain.fits
$ calGainMap.py -s /tmp/masterTF.fits -o /tmp/masterGain.fits -L 0.7 -H 1.2
```

dxtalk

PANIC HAWAII-2RG sensors with multiple parallel readout sections show crosstalk in form of compact positive and negative ghost images whose amplitude varies between readout sections. PAPI has a optional de-crosstalk module that assumes that the amplitude is the same, therefore the correction will only partially remove the effect (if at all). If you know in advance that this will be a problem for your science case, then consider choosing different camera rotator angles for your observations.

It can be activated or deactivated in the *Main config file* (remove_crosstalk=True|False).

Usage:

```
Options:
  -h, --help            show this help message and exit
  -i INPUT_IMAGE, --input_image=INPUT_IMAGE
                        input image to remove crosstalk
  -o OUTPUT_IMAGE, --output=OUTPUT_IMAGE
                        output filename (default = dxtalk.fits)
  -O, --overwrite       overwrite the original image with the corrected one
```

Example:

```
$ ./dxtalk.py -i /tmp/pruebaDC.fits -O
$ ./dxtalk.py -i /tmp/pruebaDC.fits -o /tmp/pruebaDC_dx.fits
```

makeobjmask

Creates object masks (SExtractor OBJECTS images) for a list of FITS images or a single FITS image. Expects the command "sex" (SExtractor Version 2+) in path. If weight maps exist they will be used (assume weight map

filename given by replacing .fits with .weight.fits).

The module can produce single poing masks,i.e, a single pixel set to 1 per each detected object if *single_poing* option is true.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -s INPUTFILE, --file=INPUTFILE
                        It can be a source file listing data frames or a single FITS file to proc
  -o OUTPUTFILE, --output=OUTPUTFILE
                        Output text file including the list of objects mask files created by SExt
  -m MINAREA, --minarea=MINAREA
                        SExtractor DETECT_MINAREA (default=5)
  -t THRESHOLD, --threshold=THRESHOLD
                        SExtractor DETECT_THRESH (default=2.0)
  -l SATURLEVEL, --saturlevel=SATURLEVEL
                        SExtractor SATUR_LEVEL (default=300000)
  -1, --single_point    Create a single point object mask (default=False)
```

Example:: $ ./makeobjmask.py -s /tmp/reduced_SEQ.fits -o /tmp/obj_mask.txt $ ./makeobjmask.py -s /tmp/reduced_SEQ.fits -o /tmp/obj_mask.txt -1 -l 100000 -m 10

`photometry`

This module receives a reduced image of any known NIR filter and match to 2MASS catalog performing a fit in order to get a estimation of the Zero Point. It is based on the method followed here

```
http://www.ast.cam.ac.uk/ioa/research/vdfs/docs/reports/2masscal.pdf
```

Usage:

```
Options:
  -h, --help            show this help message and exit
  -i INPUT_IMAGE, --input_image=INPUT_IMAGE
                        Input image to calibrate to do photometric comparison with
  -c BASE_CATALOG, --base_catalog (2MASS, USNO-B)=BASE_CATALOG
                        Name of base catalog to compare with (2MASS, USNO-B) -- not used !!! (def
  -S SNR, --snr=SNR     Min SNR of stars used for linear fit (default = 10.0)
  -z ZERO_POINT, --zero_point=ZERO_POINT
                        Initial Magnitude Zero Point estimation [25.0]; used for SExtractor
  -o OUTPUT_FILENAME, --output=OUTPUT_FILENAME
                        Output plot filename (default = photometry.pdf)
```

Example:

```
$ photometry.py -i /data/reduced.fits -o /tmp/calibration.pdf
```

`correctNonLinearity`

HAWAII-2RG near-IR detectors exhibit an inherent non-linear response. It is caused by the change of the applied reverse bias voltage due to the accumulation of generated charge. The effect increases with signal levels, so that the measured signal deviates stronger from the incident photon number at higher levels, and eventually levels out when the pixel well reaches saturation.

The `correctNonLinearity` module corrects PANIC images for their count-rate dependent non-linearity. It used the header keywords READMODE and DET_ID to determine the correction. It corrects the first image, and in the case of a multi-extension image, the second image as well, with the appropriate power law. For details see PANIC detector non-linearity correction data.

Usage:

```
Options:
  -h, --help            show this help message and exit
  -m MODEL, --model=MODEL
                        FITS MEF-cube file of polinomial coeffs (c4, c3, c2, c1).
  -s SOURCE_FILE_LIST, --source=SOURCE_FILE_LIST
                        Source file list of FITS files to be corrected.
  -o OUT_DIR, --out_dir=OUT_DIR
                        filename of out data file (default=/tmp)
  -S SUFFIX, --suffix=SUFFIX
                        Suffix to use for new corrected files.
  -f, --force           Force Non-linearity correction with no check of headervalues (NCOADD, DATI
```

solveAstrometry

Performs the astrometric calibration of a set of images, in principle previously reduced, but not mandatory; this routine is built on top of Astromety.net tool.

Usage:

```
Options:

-h, --help            show this help message and exit
-s SOURCE_FILE, --source=SOURCE_FILE
                        Source file list of data frames. It can be a file or directory name.
-o OUTPUT_DIR, --output_dir=OUTPUT_DIR
                        Place all output files in the specified directory [default=/tmp]
-p PIXEL_SCALE, --pixel_scale=PIXEL_SCALE
                        Pixel scale of the images
-r, --recursive       Recursive subdirectories (only first level)
```

remove_cosmics

Remove the cosmic ray hits in the input image; it is built on top of Pieter van Dokkum's L.A.Cosmic algorithm.

Usage:

```
Options:

-h, --help            show this help message and exit
-i INPUT_IMAGE, --input_image=INPUT_IMAGE
                        input image to remove cosmics
-o OUTPUT_IMAGE, --output=OUTPUT_IMAGE
                        output filename (default = without_cosmics.fits)
-O, --overwrite       overwrite the original image with the corrected one
-m, --mask            If true, the mask with cosmics detected and removed is written into a FITS
```

2.8.2 Utilities

Besides the modules for data reduction, PAPI has a set of utilities than can be used as tools for preparing the data reduction execution; they are:

Utilities	Description
`check_papi_modules`	Check whether all python modules required by PAPI are installed
`checkQuality`	Computes some quality values from the image (FWHM, STD, RMS)
`collapse`	Collapse (sum) each cube of a list of files into a single 2D image
`eval_focus_serie`	Finds out the best Focus value from a focus series
`genLogsheet`	Creates a log sheet from a set of FITS files
`health`	Compute the Gain and Noise from a set of flat images grouped in packets and with increased level of Integration Time
`imtrim`	Cut/crop edges of the input image
`modFits`	Modifies a keyword inside a FITS header
`skyfilter`	Subtracts sky background to a dither sequence of frames
`spatial_noise`	Compute the Spatial Noise from a set of dark images grouped in pairs with the same Integration Time

check_papi_modules

Check whether all Python modules required by PAPI are installed. The modules currently required are:

Module	Version
Numpy	1.6
PyRaf	1.1
PyFITS	3.0
Matplotlib	0.98.1
Scipy	0.10
PyQt4.QtCore	4.8
PyWCS	1.11
vo	0.7
Atpy	0.95

Example:

```
$ check_papi_modules.py

PAPI Python checking tool
=========================

Checking Python Version:
PAPI needs Python Version 2.Y with Y>=2.7
Your Python version 2.7.3 is fine!

Testing Python module installation for module 'atpy':
PAPI needs at least version 0.9.5
Your version 0.9.6 of 'atpy' is fine!

Testing Python module installation for module 'scipy':
PAPI needs at least version 0.10
Your version 0.10.1 of 'scipy' is fine!

Testing Python module installation for module 'pywcs':
PAPI needs at least version 1.11
Your version 1.11-4.10 of 'pywcs' is fine!

Testing Python module installation for module 'PyQt4.QtCore':
PAPI needs at least version 4.8
Your version 4.9.1 of 'PyQt4.QtCore' is fine!

Testing Python module installation for module 'vo':
PAPI needs at least version 0.7
Your version 0.8 of 'vo' is fine!
```

```
Testing Python module installation for module 'numpy':
PAPI needs at least version 1.6
Your version 1.6.2 of 'numpy' is fine!

Testing Python module installation for module 'pyraf':
PAPI needs at least version 1.1
Your version 2.0 of 'pyraf' is fine!

Testing Python module installation for module 'matplotlib':
PAPI needs at least version 0.98.1
Your version 1.1.0 of 'matplotlib' is fine!

Testing Python module installation for module 'pyfits':
PAPI needs at least version 3.0
Your version 3.1.0 of 'pyfits' is fine!
```

collapse

Sum the planes of each cube of a list files into a single plane 2D-image.

```
Usage: collapse.py [options] arg1 arg2 ...

Options:
-h, --help            show this help message and exit
-i INPUT_IMAGE, --input_image=INPUT_IMAGE
                        input cube image to collapse into a 2D image
-l INPUT_IMAGE_LIST, --input_image_list=INPUT_IMAGE_LIST
                        input image list to collapse into a single 2D image
-o OUTPUT_FILE, --output_file=OUTPUT_FILE
                        output filename (default = /tmp/out.fits)
```

Example:

```
$ collapse -i /data/mycube.fits -o /data/anymore_a_cube.fits

$ collapse -l /data/list.txt -o /data/anymore_a_cube.fits
```

checkQuality

The `checkQuality` module computes some initial image quality estimations using SExtractor.

eval_focus_series

The `eval_focus_series` module computes the best focus estimation for a focus exposure series. It is done according to the FWHM value estimated for each frame, fitting a curve the the values pair values (FWHM,focus) and finding out the minimun.

- Requirements
  - T-FOCUS (telescope focus) keyword value present in the header
  - (Raw) Images with enought number of stars
  - A series of images taken with covering a range of telescope focus values including the best focus value.

`genLogsheet`

`health`

`imtrim`

`modFits`

`skyfilter`

The `skyfilter` module uses the external package `irdr_skyfilter` to perform the sky background subtraction from a dither sequence of science frames. It works with almost all kind of dither sequences, even with sequences used for extended objects (T-S-T-S- ...., T-T-S-T-T-S-T-T-....)

For more details on `skyfilter` see the Appendix section skyfilter.

`spatial_noise`

2.9 Data formats

This section gives a description of the raw data produced by PANIC and how they are organized. However, for a deeper description, see the GEIRS manual.

2.9.1 Detector

The detector is an array (FPA) of four HAWAII-2RG detectors. The inter-chip gap between the detectors is only 167 pixels (or 75 arcsec at the 2.2m telescope) and is filled by dithering with sufficient amplitude. For applications which image only 30x30 arcmin this design is ideal.

HAWAII-2RG detectors have an effective surface of 2040x2040 sensitive pixels. A 4-pixel wide border is used as reference to correct for relatively slow bias drifts.

2.9.2 FITS

GEIRS, the software part in charge of the data acquisition and saving, is capable of saving the frames in different FITS (Flexible Image Transport System) formats (integrated, FITS-cubes, MEF, etc). Next ones are available in the Observation Tool (OT) when an OP (Observing Program) is defined:

- Multi-Extension FITS (MEF) - Integrated
- Multi-Extension FITS (MEF) - Cube
- Integrated All (SEF - Integrated)
- FITS Cube (SEF - Cube)
- Individual (SEF - Individual)

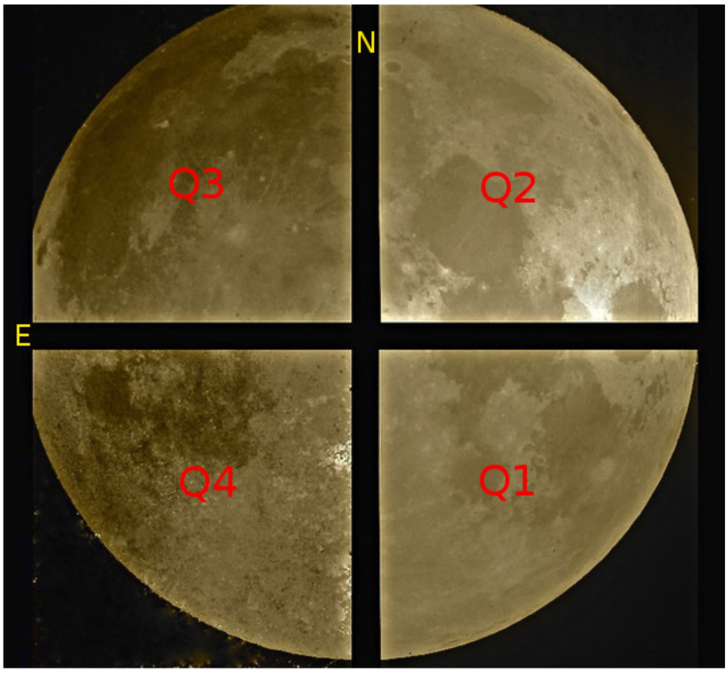
However, PAPI does not accept any kind of FITS data files available in GEIRS, only the configured in the OT, except *Individual*. As result, PAPI accepts the next type of FITS files (in order of preference):

  - Integrated Multi-Extension-FITS (MEF): a unique FITS file with four extensions (MEF), where each extension corresponds to one of the 4 images produced by the single detector chips. If the number of coadd (NCOADDS) is > 0, then they will be integrated (arithmetic sum) in a single image. This is the default and more common saving mode used; in fact, it is the **default** and more wished saving mode. This mode will also be used when the software or hardware sub-windowing is set and the integrated option is selected. Then, there will be an extension for each sub-window.

- Non-integrated Multi-Extension-FITS (MEF): a unique FITS file with four extensions (MEF), one per each detector (or window), having each extension N planes, where N is the number of coadds (NCOADDS), ie. a cube of N planes. This mode will be also used when the software or hardware subwindowing is set up and the no-integrated option is selected.
- Single integrated FITS file: the four detectors are saved in single file and in a single extension FITS image (SEF). If the number of coadds (NCOADDS) is > 0, then they are integrated (arithmetic sum) in a single frame.
- Single non-integrated FITS-cube: the four detectors are saved in a single extension FITS (SEF) file, and each individual exposition in a plane/layer of a cube. It means N planes, where N is the number of coadds or expositions.

Note: Currently PAPI is **not working** with non-integrated individual files of an exposition. In case you are interested in no-integrated files and wish to reduce the data with PAPI, you should use SEF of MEF non-integrated FITS-cube mode.

Beware that the order of the chip in the raw image produced is as described in next figure:



Next table shows the mapping of extension/quadrant names and detectors:

Extension Name	Q1	Q2	Q3	Q4
Detector Hw ID	SG1	SG2	SG3	SG4

Note that the order of the extensions in the FITS file is Q1 (ext. 1), Q2 (ext. 2), Q3 (ext. 3) and Q4 (ext. 4).

2.9.3 Headers

The header keywords currently used in a raw PANIC FITS file is as shown bellow:

Primary Header

```
SIMPLE  =                    T
BITPIX  =                   32
NAXIS   =                    2 / 2
NAXIS1  =                 4096
NAXIS2  =                 4096
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
BSCALE  =                   1.
BZERO   =                   0. / [adu] real = bzero + bscale*value
BUNIT   = 'adu     '           / [adu]
MJD-OBS =          57170.68257 / [d] Modified julian date 'days' of observation
DATE-OBS= '2015-05-28T16:22:54.0402' / [d] UT-date of observation end
DATE    = '2015-05-28T16:22:54' / file creation date (YYYY-MM-DDThh:mm:ss UT)
UT      =         58974.040247 / [s] 16:22:54.0402 UTC at EOread
LST     =         30949.087329 / [s] local sidereal time: 08:35:49.087 (EOread)
ORIGIN  = 'Centro Astronomico Hispano Aleman (CAHA)'
OBSERVER= 'Mathar  '
TELESCOP= 'CA-2.2  '
FRATIO  = 'F/08    '           / [1]
OBSGEO-L=            -2.546135 / [deg] telescope geograph. longit. 2015A&A..574A
OBSGEO-B=            37.223037 / [deg] telescope geograph. latit. 2015A&A..574A.
OBSGEO-H=                2168. / [m] above sea level 2015A&A..574A..36R
LAMPSTS = '        '           / calib. lamp
INSTRUME= 'PANIC   '           / PAnoramic Near Infrared camera for Calar Alto
CAMERA  = 'HgCdTe (4096x4096) IR-Camera (4 H2RGs)'
PIXSCALE=                 0.45 / [arcsec/px]
EGAIN1  =                 4.84 / [ct] electrons/DN
EGAIN2  =                 4.99 / [ct] electrons/DN
EGAIN3  =                 5.02 / [ct] electrons/DN
EGAIN4  =                 5.45 / [ct] electrons/DN
ENOISE1 =                  16. / [ct] electrons/read ems=1
ENOISE2 =                 16.6 / [ct] electrons/read ems=1
ENOISE3 =                 18.5 / [ct] electrons/read ems=1
ENOISE4 =                 17.9 / [ct] electrons/read ems=1
ROVER   = 'MPIA IR-ROelectronic Vers. 3' / Version det. electronics
WPOS    =                    5 / [ct] number of GEIRS wheels
W1POS   = 'Coldstop22'
W2POS   = 'H       '
W3POS   = 'Ks      '
W4POS   = 'dummy   '
W5POS   = 'Black   '
FILTER  = 'NO      '           / filter macro name of filter combinations
STRT_INT=         58943.164225 / [s] 16:22:23.1642 start integration (UT)
STOP_INT=         58946.502476 / [s] 16:22:26.5025 stop integration (UT)
RA      =             172.8182 / [deg] R.A.: 11:31:16.4
DEC     =            33.088802 / [deg] Dec.: +33:05:20
EQUINOX =                2000. / [a] Julian Epoch
OBSEPOCH=          2015.403645 / [a] Julian Epoch
AIRMASS =             1.232127 / [1] airmass
HA      =           316.144687 / [deg] H.A. '21:04:34.72'
T_FOCUS =                   0. / [mm] telescope focus
CASSPOS =                   0. / [deg] cassegrain position rel. to NSEW
OBJECT  = 'unknown '           / telescope target
POINT_NO=                    0 / [ct] pointing counter
DITH_NO =                    0 / [ct] dither step
EXPO_NO =                    2 / [ct] exposure/read counter
FILENAME= 'test_0001.fits'
FILE_ID = 'Panic.2015-05-28T16:22:23.164_0001_001' / instru., time, image, windo
TPLNAME = '        '           / macro/template name
TIMER0  =                 2740 / [ms]
```

```
TIMER1  =                 2740 / [ms]
TIMER2  =                    0 / [us]
PTIME   =                    2 / pixel-time-base index
PREAD   =                10000 / [ns] pixel read selection
PSKIP   =                  150 / [ns] pixel skip selection
LSKIP   =                  150 / [ns] line skip selection
READMODE= 'line.interlaced.read' / read cycle-type
IDLEMODE= 'wait    '           / idle to read transition
IDLETYPE= 'ReadWoConv'         / idle cycle-type
SAVEMODE= 'line.interlaced.read' / save cycle-type
NEXP    =                    1 / cycle repeat count
CPAR1   =                    1 / cycle type parameter
ITIME   =             2.739931 / [s] (on chip) integration time
CTIME   =             5.481201 / [s] read-mode cycle time
HCOADDS =                    1 / [ct] # of hardware coadds
EMSAMP  =                    1 / [ct] electronic multi-sampling
PCOADDS =                    1 / [ct] # of coadded plateaus/periods
SCOADDS =                    1 / [ct] # of software coadds
SWMSAMP =                    1 / [ct] # software multisampling
NCOADDS =                    1 / [ct] effective coadds (total)
EXPTIME =             2.739931 / [s] total integ. time
FRAMENUM=                    1 / of 1 saved
SKYFRAME= 'unknown '
DETSEC  = '[1:4096,1:4096]'    / [px] xrange and yrange of window
DATASEC = '        '           / [px] xy-range of science data
DETSIZE = '[1:4096,1:4096]'    / [px] full size of the 4 detector mosaic
CHIPSIZX=                 2048 / [px] single chip pixels in x
CHIPSIZY=                 2048 / [px] single chip pixels in y
DETROT90=                    0 / [ct] 90 deg SW image cw rotations
DETXYFLI=                    0 / [1] SW image flip (1=RightLeft, 2=UpDown)
B_EXT1  =             2.679688 / [V] external bias 2744
B_EXT2  =             2.679688 / [V] external bias 2744
B_EXT3  =             2.679688 / [V] external bias 2744
B_EXT4  =             2.679688 / [V] external bias 2744
B_DSUB1 =             1.569727 / [V] det. bias voltage DSUB 3420
B_DSUB2 =             1.569727 / [V] det. bias voltage DSUB 3420
B_DSUB3 =             1.569727 / [V] det. bias voltage DSUB 3420
B_DSUB4 =             1.569727 / [V] det. bias voltage DSUB 3420
B_VREST1=              1.07999 / [V] det. bias voltage VRESET 2353
B_VREST2=              1.07999 / [V] det. bias voltage VRESET 2353
B_VREST3=              1.07999 / [V] det. bias voltage VRESET 2353
B_VREST4=              1.07999 / [V] det. bias voltage VRESET 2353
B_VBIAG1=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG2=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG3=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VBIAG4=             2.199707 / [V] det. bias voltage VBIASGATE 3604
B_VNBIA1=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA2=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA3=                   0. / [V] det. bias voltage VNBIAS 0
B_VNBIA4=                   0. / [V] det. bias voltage VNBIAS 0
B_VPBIA1=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA2=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA3=                   0. / [V] det. bias voltage VPBIAS 0
B_VPBIA4=                   0. / [V] det. bias voltage VPBIAS 0
B_VNCAS1=                   0. / [V] det. bias voltage VNCASC 0
B_VNCAS2=                   0. / [V] det. bias voltage VNCASC 0
B_VNCAS3=                   0. / [V] det. bias voltage VNCASC 0
B_VNCAS4=                   0. / [V] det. bias voltage VNCASC 0
B_VPCAS1=                   0. / [V] det. bias voltage VPCASC 0
B_VPCAS2=                   0. / [V] det. bias voltage VPCASC 0
B_VPCAS3=                   0. / [V] det. bias voltage VPCASC 0
B_VPCAS4=                   0. / [V] det. bias voltage VPCASC 0
B_VBOUB1=                   0. / [V] det. bias voltage VBIASOUTBUF 0
```

```
B_VBOUB2=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB3=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_VBOUB4=                    0. / [V] det. bias voltage VBIASOUTBUF 0
B_REFSA1=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA2=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA3=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFSA4=                    0. / [V] det. bias voltage REFSAMPLE 0
B_REFCB1=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB2=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB3=                    0. / [V] det. bias voltage REFCOLBUF 0
B_REFCB4=                    0. / [V] det. bias voltage REFCOLBUF 0
TEMP_A  =             79.068001 / [K] Moly frame (-194.08 C)
TEMP_B  =             79.999001 / [K] Detector (-193 C)
PRESS1  =               1.0E-05 / [Pa] (1.020e-10 bar) , 'pressure1'
TEMPMON =                     8 / [ct] # of temp. monitrd 2015-05-28 16:21 loc. t
TEMPMON1=             84.508003 / [K] (-188.64 C) Cold plate
TEMPMON2=                97.056 / [K] (-176.09 C) Lens Mount 1
TEMPMON3=             85.961998 / [K] (-187.19 C) Charcoal
TEMPMON4=             75.846001 / [K] (-197.30 C) LN2 detector tank
TEMPMON5=             87.633003 / [K] (-185.52 C) Filter wheel housing
TEMPMON6=             94.026001 / [K] (-179.12 C) Preamps
TEMPMON7=             79.591003 / [K] (-193.56 C) LN2 main tank
TEMPMON8=                89.347 / [K] (-183.80 C) Radiation shield
CREATOR = 'GEIRS : trunk-r737M-13 (May 28 2015, 16:17:00), Panic'
COMMENT = 'no comment'
OBSERVAT= 'CAHA    '           / Calar Alto, Almeria, Andalucia, Spain, panic.ca
OPCYCL  =                     9 / Operation cycle number
OPDATE  = '2015-04-28T15:16:00' / UT-date of operation cycle start
MNTCYCL =                     7 / Mounting cycle number
MNTDATE = '2015-01-29T15:00:00' / UT-date of mounting cycle start
HIERARCH CAHA AMBI WINSP = 4.5 / [m/s] wind speed day=20150528 UT=1448
HIERARCH CAHA AMBI WINDIR = 149. / [deg] wind direction day=20150528 UT=1448
HIERARCH CAHA AMBI TEMP = 15.2 / [C] temperature day=20150528 UT=1448
HIERARCH CAHA AMBI HUMI =   46 / [%] rel. humidity day=20150528 UT=1448
HIERARCH CAHA AMBI DEWP =  3.7 / [C] dew point day=20150528 UT=1448
HIERARCH CAHA AMBI PRESS = 778. / [hPa] air pressure day=20150528 UT=1448
HIERARCH CAHA AMBI CLOUD = -25.7 / [] cloud sensor day=20150528 UT=1448
COMMENT Linux panic22 3.11.6-4-desktop #1 SMP PREEMPT Wed Oct 30 18:04:56 UTC 20
COMMENT 13 (e6d4a27) x86_64
COMMENT Plx API Version 7.10
EOFRM000=         58943.164227 / [s] 16:22:23.1642 UTC past midnight
EOFRM002=         58944.177113 / [s] 16:22:24.1771 +1.01289 UTC past midnight
END
```

Extensions Header (SG1)

```
XTENSION= 'IMAGE   '           / IMAGE extension
BITPIX  =                    32 / number of bits per data pixel
NAXIS   =                     2 / number of data axes
NAXIS1  =                  2048 / length of data axis 1
NAXIS2  =                  2048 / length of data axis 2
PCOUNT  =                     0 / required keyword; must = 0
GCOUNT  =                     1 / required keyword; must = 1
EXTNAME = 'Q1      '
HDUVERS =                     1
DETSEC  = '[2049:4096,1:2048]' / [px] section of DETSIZE
DATASEC = '[5:2044,5:2044]'    / [px] section of CHIPSIZ
PERCT025=                 2688. / 2.5 % percentile ADU
PERCT050=                 2700. /   5 % percentile ADU
PERCT075=                 2705. / 7.5 % percentile ADU
PERCT100=                 2708. /  10 % percentile ADU
PERCT125=                 2712. / 12.5 % percentile ADU
PERCT150=                 2714. /  15 % percentile ADU
```

```
PERCT175=                2716. / 17.5 % percentile ADU
PERCT200=                2718. /  20 % percentile ADU
PERCT225=                2720. / 22.5 % percentile ADU
PERCT250=                2723. /  25 % percentile ADU
PERCT275=                2725. / 27.5 % percentile ADU
PERCT300=                2726. /  30 % percentile ADU
PERCT325=                2728. / 32.5 % percentile ADU
PERCT350=                2730. /  35 % percentile ADU
PERCT375=                2732. / 37.5 % percentile ADU
PERCT400=                2733. /  40 % percentile ADU
PERCT425=                2735. / 42.5 % percentile ADU
PERCT450=                2736. /  45 % percentile ADU
PERCT475=                2738. / 47.5 % percentile ADU
PERCT500=                2739. /  50 % percentile ADU
PERCT525=                2741. / 52.5 % percentile ADU
PERCT550=                2743. /  55 % percentile ADU
PERCT575=                2745. / 57.5 % percentile ADU
PERCT600=                2746. /  60 % percentile ADU
PERCT625=                2748. / 62.5 % percentile ADU
PERCT650=                2749. /  65 % percentile ADU
PERCT675=                2750. / 67.5 % percentile ADU
PERCT700=                2753. /  70 % percentile ADU
PERCT725=                2754. / 72.5 % percentile ADU
PERCT750=                2756. /  75 % percentile ADU
PERCT775=                2758. / 77.5 % percentile ADU
PERCT800=                2760. /  80 % percentile ADU
PERCT825=                2763. / 82.5 % percentile ADU
PERCT850=                2765. /  85 % percentile ADU
PERCT875=                2768. / 87.5 % percentile ADU
PERCT900=                2772. /  90 % percentile ADU
PERCT925=                2776. / 92.5 % percentile ADU
PERCT950=                2780. /  95 % percentile ADU
PERCT975=                2787. / 97.5 % percentile ADU
RA      =           332.367528 / [deg] R.A.: 22:09:28.2
DEC     =            51.084307 / [deg] Dec.: +51:05:04
PIXSCALE=                 0.45 / [arcsec/px]
CUNIT1  = 'deg     '           / WCS units along axis 1
CUNIT2  = 'deg     '           / WCS units along axis 2
CTYPE1  = 'RA---TAN'           / WCS axis 1
CTYPE2  = 'DEC--TAN'           / WCS axis 2
CRVAL1  =     332.36752753434 / [deg] RA in mosaic center
CRVAL2  =    51.0843069975685 / [deg] DEC in mosaic center
CD1_1   = -0.000124999996688631 / [deg/px] WCS matrix diagonal
CD2_2   = 0.000124999996688631 / [deg/px] WCS matrix diagonal
CD1_2   = -2.56379278852432E-14 / [deg/px] WCS matrix outer diagonal
CD2_1   = -2.56379278852432E-14 / [deg/px] WCS matrix outer diagonal
CRPIX1  =                  -81 / [px] RA and DEC center along axis 1
CRPIX2  =                 2132 / [px] RA and DEC center along axis 2
DET_ID  = 'SG1     '           / lower right (SW) chip
COMMENT WCS assumes CHIPGAPX=167, CHIPGAPY=167, north=90 deg
BSCALE  =                   1.
BZERO   =                   0.
END
```

2.9.4 Observation Tool keywords

Next keywords are automatically added to the FITS header by the PANIC Observation Tool (OT), as each file is created. If these are not saved, neither PAPI nor PQL will work correctly:

```
OBS_TOOL= 'OT_V1.1 '           / PANIC Observing Tool Software version
PROG_ID = '        '           / PANIC Observing Program ID
```

```
OB_ID    = '6        '             / PANIC Observing Block ID
OB_NAME = 'OB CU Cnc Ks 2'         / PANIC Observing Block Name
OB_PAT   = '5-point '              / PANIC Observing Block Pattern Type
PAT_NAME= 'OS Ks 2 '               / PANIC Observing Secuence Pattern Name
PAT_EXPN=                        1 / PANIC Pattern exposition number
PAT_NEXP=                        5 / PANIC Pattern total number of expositions
IMAGETYP= 'SCIENCE '               / PANIC Image type
```

2.9.5 Data

Raw images pixels are coded with 32-bit signed integers (BITPIX=32), however final reduced images are coded with 32-bit single precision floating point (BITPIX=-32). The layout of each chip image in a raw image is described above.

2.9.6 Classification

Any raw frame can be classified on the basis of a set of keywords read from its header. Data classification is typically carried out by the Pipeline at start or by PQL, that apply the same set of classification rules. The association of a raw frame with calibration data (e.g., of a science frame with a master dark frame) can be obtained by matching the values of a different set of header keywords (filter, texp, ncoadds, itime, readmode, date-obs, etc). Each kind of raw frame is typically associated to a single PAPI pipeline recipe, i.e., the recipe assigned to the reduction of that specific frame type. In the pipeline environment this recipe would be launched automatically. In the following, all PANIC raw data frames are listed, together with the keywords used for their classification and correct association.

Type	Description
`DARK`	Dark frame
`DOME_FLAT`	Dome flat-field frame (lamp on/lamp off)
`SKY_FLAT`	Sky flat-field frame
`FOCUS`	Focus frame of a focus series
`SCIENCE`	Science frame
`SKY`	Sky frame (mostly clear) used for extended object reduction

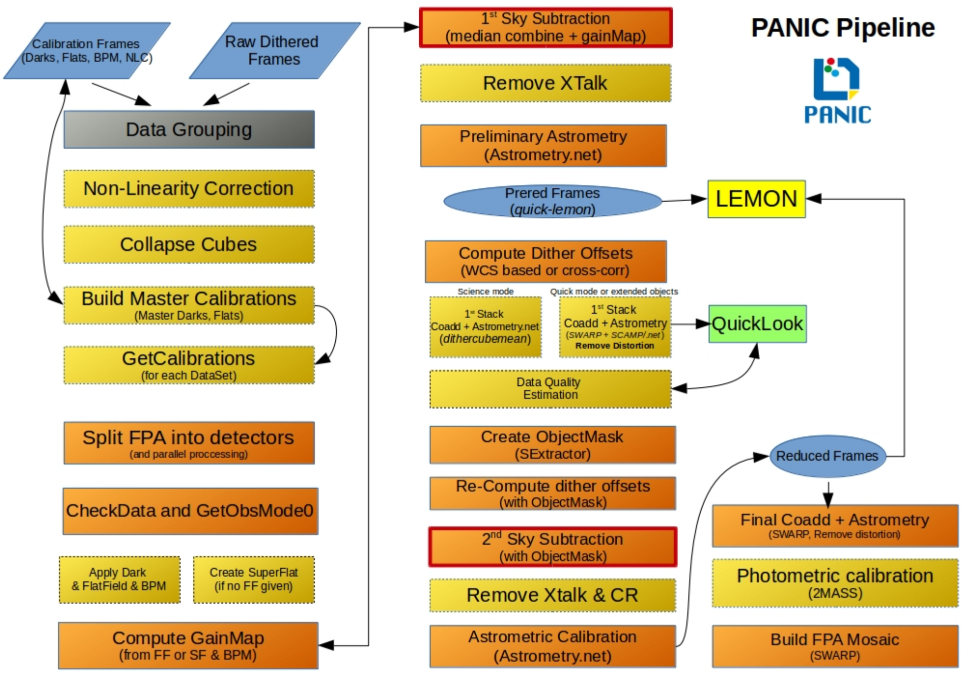
2.9.7 Data grouping

Once the raw files are classified, they are grouped into observing sequences, taking into account the *keywords* added by the Observation Tool (OT), and finding out the dither sequences observed. This way, all files beloging to the same observing sequence will be processed together.

2.10 Processing description

This section gives a description of each step of the pipeline in a greater detail and list the parameters that can be changed if needed.

Next figure shows the main steps that are involved in the PANIC pipeline:



2.10.1 Outline

- the non-linearity is corrected;
- a master flat-field in computed by combining all the appropriate images without offsets; if the mosaic is of an Sky-Target type, only the sky frames are used;
- a bad pixel mask, is computed by detecting, in the master flat field, the pixels with deviant values;
- if provided, an external bad pixel mask is also used, adding the bad pixel in the previus one;
- for each image, a sky frame is computed by combining a certain number of the closest images;
- this sky frame is subtracted by the image and the result is divided by the master flat;
- bright objects are detected by SExtractor in these cleaned images to measure the offsets among the images; the object mask are multiplied by the bad pixel mask to remove false detections;
- a cross-correlation algorithm among the object masks is used to measure the relative offsets. It also works if no object is common to all the images;
- the cleaned images are combined using the offsets, creating the "quick" image;
- to remove the effect of faint obejcts on the estimate of the sky frames, SExtractor is used on the combined image to create a master object mask;
- the object mask is dilatated by a certain factor to remove also the undetected object tails;
- for each image a new sky is computed by taking into account this object mask;
- if field distortion can be neglected, these images are combined by using the old offsets, creating the "science" image;
- field distortion is removed from the cleaned images by using SCAMP computed distortion model
- the pixels containing deviant pixels are identified and flagged;
- the old offsets could be effected by field distortion, therefore new offsets are computed for the undistorted images;

- finally, the cleaned corrected images are combined.

Main configuration file

See *Main config file*

Data-set classification

One of the main features of PAPI is that the software is able to do an automatic data reduction. While most of the pipelines are run interactively, PAPI is able to run without human interaction. It is done because of the classificaton algorithm that is implemented in PAPI and that allow an automatic identification of the data sets grouping the files according to the observation definition with the OT.

1 - The data grouping algorithm 2 - Sky finding algorithm for extended objects

In case of not using the OT during the observation, also a data grouping is possible, althouth with some limitations. Let's see how it works:

[...]

Data Preparation

Firstly, each FITS file is linearity corrected if it was enabled in the configuration file (nonlinearity:apply). If integrations where done with repetitions >1 and saved as a cube with N-planes, then the FITS cube is collapsed doing a simple arithmetich sum of N-planes.

Then the image is divided into the number of chips in the FPA (which constitutes 4 chips in a mosaic). From this step on, the pipeline works on individual chips rather than whole images, thereby enhancing the speed and enabling us to do multi-chip processing on multi CPUs.

Calibrations

In next sections we describe the main calibration to be done by PAPI.

2.10.2 Computing the master dark

TBC

2.10.3 Computing the master flat-field

TBC

2.10.4 Computing the Bad Pixel Mask

The map of all bad pixels (hot, low QE) are derived from the non-linearity tests. However, also the nonlinearity analysis provides a list of non-correctable pixels, which always will be considered invalid.

So, currently there is no procedure in PAPI to compute the right bad pixel mask (BPM).

First pass sky subtraction

2.10.5 Sky model

TBC

Object detection

Offset computation

First pass coaddition

Master object mask

SExtractor is again used to find objects in this first-pass coadded image in order to mask then during next sky estimation. This time the parameters controlling the detection threshold should be set to have deeper detections and mask faint objects. The parameters involved nad ther default values are:

mask_minarear = 10 mask_thresh = 1.5

The resulting object mask is extended by a certain fraction to reject also the undetected object tails.

Non-Linearity

HAWAII-2RG near-IR detectors exhibit an inherent non-linear response. It is caused by the change of the applied reverse bias voltage due to the accumulation of generated charge. The effect increases with signal levels, so that the measured signal deviates stronger from the incident photon number at higher levels, and eventually levels out when the pixel well reaches saturation.

The common approach is to extrapolate the true signal Si(t) from measurements with low values, and fit it as a function of the measured data S(t) with a polynomial of order n:

For the correction, PAPI uses a master Non-Linearity FITS file that store the fit to be applied to the raw images. There is file for each readout mode. The filename is composed as:

```
mNONLIN_<readmode>_<version>.fits
```

The FITS file has a primary header with no data, and two data extensions for each detector. They are labeled LINMAX<i> and LINPOLY<i> with i=1...4 being the quadrant index, numbered similar to the scheme for MEF data files from GEIRS. Note that the indices do not necessarily correspond to SG hardware IDs, which are written in the header instead.

The extension LINMAX<i> is a 32bit float 2048x2048 data array containing the maximum correctable signal for each detector. Uncorrectable pixels have a NaN instead of a numerical value. The extension and LINPOLY<i> is a 32bit float 2048x2048x4 data cube containing the polynomial coefficients c[1...4] in reverse order. The first slice in the cube is c[4], the second c[3], etc.

The module used to correct the non-linearity is `correctNonLinearity.py`; in adition the non-linearity correction can be enable in the configuration file $PAPI_CONFIG setting in the *nonlinearity* section the keyword *apply = True*.

Crosstalk

HAWAII2 sensors with multiple parallel readout sections can show crosstalk in form of compact positive and negative ghost images whose amplitude varies between readout sections. PAPI has a optional de-crosstalk module that assumes that the amplitude is the same, therefore the correction will only partially remove the effect (if at all). If you know in advance that this will be a problem for your science case, then consider choosing different camera rotator angles for your observations.

The first effort at characterizing and removing the cross-talks made use of the “Medamp” technique. By this we mean isolating then subtracting what is common to all 32 amplifiers. This effectively seems to remove the edge and negative cross-talks which both affect all 32 amplifiers. But it does not remove the positive crosstalk. Note that the assumption is that the amplitude of the edge and negative cross-talks is the same ona ll 32 channels. We tried inconclusively to prove/disprove that assumption. If amplifier-dependant, the amplitude variations must be less than 10%.

We experimented doing the medamp at various stages of the processing and found the best results when removing the crosstalk as the very last step, after sky subtraction. Rigorously, it should actually be the very first step since crosstalk effects are produced in the very last stages of image generation.

The module used to correct the crosstalk is `dxtalk.py.py`; in adition the crosstalk correction can be enable in the configuration file $PAPI_CONFIG setting in the *general* section the keyword *remove_crosstalk = True*.

Extended Objects

If your targets are really extended and/or very faint, then you should seriously consider observing blank SKY fields. They will be recognized and automatically used in the correct manner once identified by PAPI. No additional settings have to be made. You should check though that the images have correct header keys.

2.11 References

2.11.1 Publications

- Ibáñez Mengual, J.M., Fernández, M., Rodríguez Gómez, J. R., García Segura, A. J., Storz, C., "The PANIC software system", Proc. SPIE 7740, 77402E (2010)
- Ibáñez Mengual, J.M, García A.J, Storz C., Fried J. W., Fernández M., Rodríguez J. F., "Advanced PANIC quick-look tool using Python", Proc. SPIE 8451, (2012)

2.11.2 Webpages

- PANIC (PAnoramic Near Infrared Camera)
- Instituto de Astrofísca de Andalucía (IAA-CSIC)
- Max Planck Institute for Astronomy (MPIA)
- Calar Alto Observatory
- GEIRS
- Observation Tool (OT)
- LEMON
- Astromatic
- MultiDrizzle Handbook

2.12 PAPI FAQ

2.12.1 Installation

Does PAPI work with python 3?

It has not been tested yet, but probably it does not work.

What GUI toolkit does PAPI-QL use?

PAPI Quick-Look uses Qt toolkit.

Can PAPI-QL work with PyQt5?

It has not been tested yet, but probably it does not work.

2.12.2 Data reduction

What is the best way to reduce PAPI data?

The recommend to use the OT and execute the OBs. That way the headers will include meta-data about the observation, and thus the pipeline can group the data and find the required calibrations for a successful reduction. Then, you only have to type:

> papi -s /data1/PANIC/my_program/

How does PAPI treat bad pixels ?

See *Bad Pixel Treatment*.

How can we reach hundredth of magnitude accuracy in photometry ?

The best way to accurately photometrically calibrate PANIC images is to use 2MASS stars in the field itself to derive the photometric solution. The accuracy strongly depends on the number of bright 2MASS stars within the filed of view, but ranges from a few 1/100th of a magnitude to 0.1 magnitudes if only faint stars are contained in the field. Additionally, observing supplementary standard star fields can be asked for when preparing the observations. To perform the 2MASS photometric calibration on an image you should use the 'photometry' command as follow:

> photometry -i /directory/prereducedField.fits -o test.pdf

How good is PAPI astrometry and how are PSF variations corrected ?

At present the pipeline applies a correction for PSF distortions based on a distortion map derived during the astrometric calibration done with SCAMP (a software developped by Emmanuel Bertin) and 2MASS.

2.13 Troubleshooting

This section gives a description of some problems that can be obtained and how they can be solved.

2.13.1 Why do I get a "command not found" error when trying to run one of the PAPI modules?

If you are trying to run the command from the same directory as the executable (i.e.,$HOME/bin), make sure that your path contains "."

If you are trying to run the command from another directory, add $HOME/bin to your path.

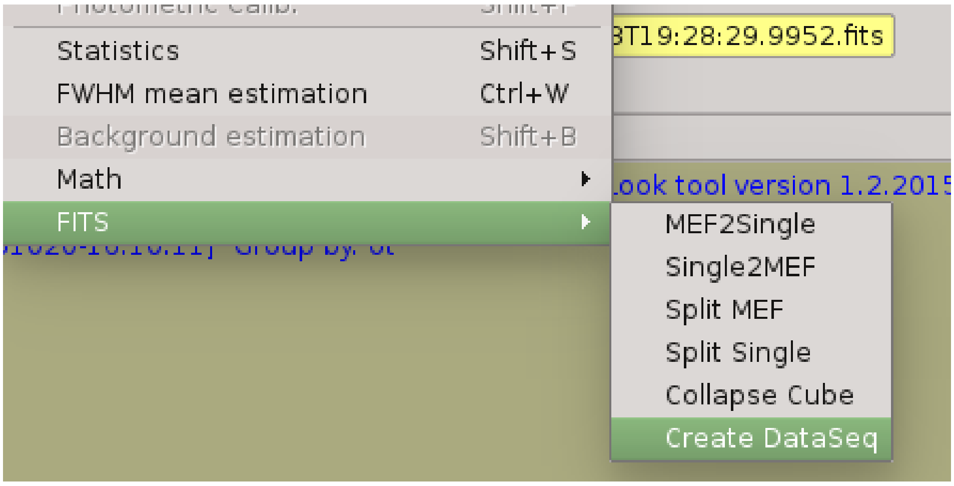
2.13.2 PAPI does not recognize a group of files as a well formed sequence.

It maybe because the sequence is missing some files of the sequence, or some of them have no proper headers (ie. they were not observed with OT).

Solutions:

- You can try to reduce the sequence using the groping mode 'filter' instead of 'ot'. It means PAPI will not use any OT header information, but RA, DEC, DATE-OBS and FILTER.

- Use the ‘Create Data Seq’ option which will create/fix a new sequence adding the required header keywords:



2.13.3 PAPI can not run the astrometric calibration

Verify that:

- You have cdsclient installed
- You have an internet connection and no firewall is blocking CDSClient
- You can config CDSClient to run with a proxy.

2.13.4 PAPI can not run the photometric calibration

Verify that:

- You have an Internet connection. It is used to query the on-line 2MASS or USNO-B catalog.
- Check that the input reduced image is astrometrically calibrated and it the filter name FILTER keyword match some of the 2MASS or USNO-B catalog.

2.13.5 PAPI says some files in the input file list does not look a FITS file.

Verify that:

- The input file is not ending with a blank/empy line.
- The file has Unix text format. Text files created on DOS/Windows machines have different line endings than files created on Unix/Linux. DOS uses carriage return and line feed (“rn”) as a line ending, which Unix uses just line feed (“n”).

2.13.6 What is the best way to reduce PAPI data?

The recommend to use the OT and execute the OBs. That way the headers will include meta-data about the observation, and thus the pipeline can group the data and find the required calibrations for a successful reduction. Then, you only have to type:

```
> papi -s /data1/PANIC/my_program/
```

2.13.7 How can we reach hundredth of magnitude accuracy in photometry ?

The best way to accurately photometrically calibrate PANIC images is to use 2MASS stars in the field itself to derive the photometric solution. The accuracy strongly depends on the number of bright 2MASS stars within the filed of view, but ranges from a few 1/100th of a magnitude to 0.1 magnitudes if only faint stars are contained in the field. Additionally, observing supplementary standard star fields can be asked for when preparing the observations. To perform the 2MASS photometric calibration on an image you should use the 'photometry' command as follow:

```
>  photometry -i /directory/prereducedField.fits -o test.pdf
```

2.13.8 How good is PAPI astrometry and how are PSF variations corrected ?

At present the pipeline applies a correction for PSF distortions based on a distortion map derived during the astrometric calibration done with SCAMP (a software developped by Emmanuel Bertin) and 2MASS.

2.13.9 Is there a way to look at or edit FITS headers?

The PAPI package includes the WCS library and tools, including a program called **edhead**. This is built automatically when you build PAPI, and it is installed into the $HOME/bin. directory.

To run **edhead**, simply type *edhead filename.fits*. It will strip the header from the FITS file and open it for editing using the program defined in your environment. Make the changes, save and exit the editor, and the header is re-attached to the image.

2.13.10 Does PAPI generate a log file of the processing ?

Yes, it can be configured in the $PAPI_CONFIG file with the parameter *logfile = /tmp/papi.log*. For each, execution, the log filename will have an suffix with the timestamp of the data and time, i.e., /tmp/papi_YYYY-MM-DDTHH:MM:SS.ss.log.

2.14 Acknowledgments

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We also thank all our colleagues from PANIC team and Calar Alto Observatory for their constructive input during the entire development process and the writing of this software.

2.15 License

2.16 Glossary

DRP Data Reduction Pipeline

IAA Instituto de Astrofísica de Andalucía

observing mode One of the prescribed ways of observing with an instrument

OT Observation Tool

PANIC Panoramic Near Infrared Camera

PAPI PANIC Pipeline

Pipeline An automated data reduction pipeline can be defined as a set of contiguous data processing operations designed to automatically transform data from one functional level to another.

Recipe A software object that processes the data obtained with a given observing mode of the instrument

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CITATION

If your research uses PAPI, we'd appreciate it if you could acknowledge the fact by including the following citation:

"This research made use of PAPI, the pipeline of PANIC instrument. It is funded by the Spanish Ministry of Economy and Competitiveness with funds from the European Union (FEDER) and the Spanish national budget, through the grants ICTS-2006-15, ICTS-2007-10, ICTS-2008-24, ICTS-2009-32 and the project Intramural 200450E458 of the Spanish National Research Council."

- Ibáñez Mengual, J.M., Fernández, M., Rodríguez Gómez, J. R., García Segura, A. J., Storz, C., "The PANIC software system", Proc. SPIE 7740, 77402E (2010)
- Ibáñez Mengual,J.M, García A.J, Storz C., Fried J. W., Fernández M., Rodríguez J. F., "Advanced PANIC quick-look tool using Python", Proc. SPIE 8451, (2012)

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